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## Original Communications

### A DEMONSTRATION OF CERVICOMEDIASTINAL CONTINUITY WITH COMMENTS ON EXTRAPLEURAL EXTENSION OF MEDIASTINAL ABSCESS


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THE various compartments of the neck formed by the layers of deep cervical fascia communicate directly with mediastinal spaces. This cervicomediastinal continuity is mentioned in most anatomic texts. Furstenberg gives a detailed description of these fasciae in neck and mediastinum, based upon a study of carefully dissected serial sections.

Briefly, according to Furstenberg, four layers of deep cervical fascia divide the neck into three compartments. The *superficial layer* invests the neck, is attached posteriorly to the ligamentum nuchae, superiorly to the external occipital protuberance, mastoid, parotid capsule, and mandible, and inferiorly, to the sternum. The *pretracheal layer* splits to enclose the thyroid gland and merges laterally with the carotid sheath. Below, it leaves the neck and passes to the aorta and pericardium, giving off an important projection which attaches to the undersurface of the sternum. Posterior to the thyroid gland, the fascial capsule formed for it by the splitting of the pretracheal fascia unites to form a single layer which passes backward behind the pharynx and esophagus to form the *buccopharyngeal* fascia. The latter comprises the anterior wall of the retropharyngeal space. Below, it extends into the posterior mediastinum behind the esophagus. The *prevertebral* fascia lies on the prevertebral musculature. Laterally, it too enters into the formation of the carotid sheath; above, it is attached to the base of the skull; below, it continues into the posterior mediastinum.

Three cervicomediastinal compartments are thus formed: (1) the *previsceral,* between the superficial and pretracheal layers, in relation


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with the anterior mediastinum but not communicating with it directly because of the fascial projection from the pretracheal layer to the sternum; (2) the *visceral,* between the pretracheal and buccopharyngeal layers, containing the thyroid, trachea, and esophagus, and communicating directly with the posterior mediastinum; and (3) the *retrovisceral,* between the buccopharyngeal and prevertebral fasciae, continuous into the posterior mediastinum. The *carotid sheath,* formed by the fusion of pretracheal, buccopharyngeal, and prevertebral layers, is the downward prolongation of the pharyngomaxillary fossa. It contains the carotid artery, the internal jugular vein, the vagus nerve, and lymphatics. In the chest, the thoracic continuations of the visceral and retrovisceral compartments exist as definite spaces in their entire downward extension. Together, they comprise the posterior mediastinum, ordinarily defined as that portion of the mediastinum posterior to the pericardium. The lymph nodes of the neck lie in the connective tissue of the above-mentioned spaces. They intercommunicate freely with each other and with the nodes of the posterior mediastinum.

The intimate relationship of the various compartments of the neck to the upper respiratory passages and to the esophagus makes abscess formation in these compartments a common occurrence. Because of the anatomic boundaries of the spaces, descent of abscess to the mediastinum occurs most commonly through the retrovisceral compartment, which, in its upper pharyngeal portion, drains the upper pharynx and overlies the tonsils. When due to trauma to the neck viscera, cervical abscesses descend in the visceral compartment into the posterior mediastinum. The more superficial cervical abscesses may involve the mediastinum by way of the lymphatics, by burrowing to or behind the carotid sheath, or by a phlegmonous infection which destroys fascial boundaries.

A unique demonstration of cervicomediastinal continuity of the entire retrovisceral space in the neck and mediastinum, from the base of the skull to the diaphragm, was afforded by a case which will be reported below. This case also illustrates a second point of considerable interest; namely, that mediastinal suppuration may extend extrapleurally along the chest wall to produce a lesion closely resembling empyema thoracis both clinically and roentgenographically.

## CASE REPORT

B. B., Mount Sinai Hospital, No. 332945, 18-month-old female infant, was admitted to Mount Sinai Hospital Dec. 4, 1931, with a history of "pneumonia followed by empyema" nine months before admission. Rib resection and drainage of the "empyema" had been performed in February, 1931. The postoperative course was reported as having been stormy. Three months after operation the infant was discharged from that hospital with a small draining chest wound remaining. The chest wound continued to drain, and this was the condition upon admission to Mount Sinai Hospital. Drainage consisted of about a dram of odorless, yellow pus daily. The general condition of the child was good. She was ambulatory, afebrile, and free of symptoms other than the discharging wound.

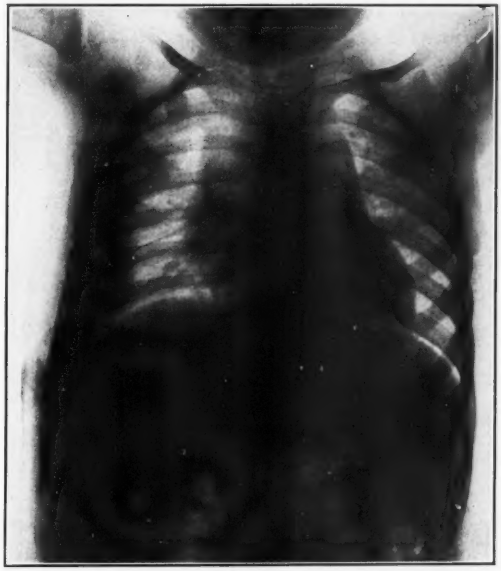

Fig. 1.—B. B., Dec. 7, 1931. Thickened pleura over right lung. Irregular right pneumothorax. Large shadow in mediastinum extending below to fuse with heart shadow.

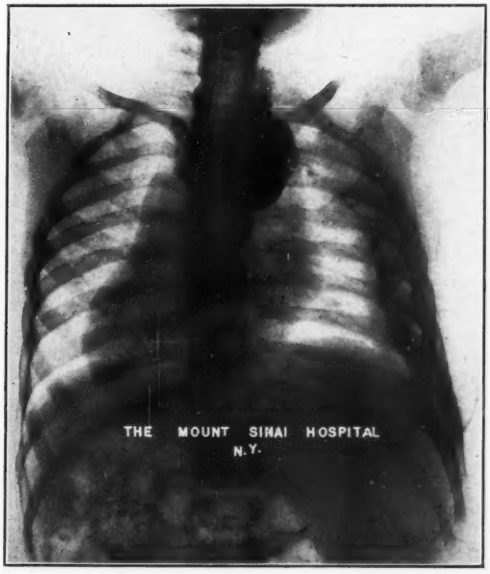


Fig. 2.—B. B., Dec. 7, 1931. Iodized oil injected into the lateral chest wall sinus extends upward over surface of lung from tenth to sixth ribs. From latter point, narrow sinus tract passes mesially and upward to superior mediastinum. From here oil passes downward in mediastinum to eighth dorsal vertebra and upward in cervicomediastinal compartment to base of skull.

Physical examination on admission revealed a well-developed child who did not appear ill. The temperature was normal. There was no pallor or emaciation. The tonsils were large, soft, and uninflamed. The trachea was mobile. No cervical adenopathy was present. The heart was normal in size, position, and action. The chest disclosed no abnormalities of expansion, resonance, or breath sounds. In the lower part of the right axilla, in the posterior axillary line, was a linear scar parallel to the intercostal spaces and bearing the orifice of the sinus tract.

Fig. 3.—B. B., Dec. 7, 1931. Lateral view showing course of injected iodized oil.

A radiograph of the chest, taken Dec. 7, disclosed thickened pleura over the entire right lung and what was apparently an irregular pneumothorax on the right side. A large shadow in the superior mediastinum extending below to fuse with the heart shadow was interpreted as a mass of enlarged lymph nodes (Fig. 1). Iodized oil was then injected into the sinus without pressure. The course it pursued was astonishing and established the diagnosis. The iodized oil passed upward over the surface of the lung from the tenth to the sixth ribs. From the latter point, a narrow sinus tract passed mesially and upward to the superior mediastinum. At this point the oil again expanded into a broad tract which passed downward along the mediastinal pleura to the eighth dorsal vertebra and upward in the posterior mediastinum into the neck. Here it continued along the prevertebral fascia to the base of the skull. There was no communication with the bronchial tree (Figs. 2 and 3).

The temperature, which had been normal until the injection of iodized oil, began to spike irregularly, reaching 104° on the sixth day (Dec. 13). Dullness on percussion was elicited over the upper lobe of the right lung, and subsequently, there was noted a wooden percussion note in the right interscapular region in the neighborhood of the first four ribs.

Accordingly, the posterior mediastinum was explored in the expectation of encountering a mediastinal abscess. On Dec. 15, a paravertebral incision was made and short sections of the fifth and sixth ribs were excised. The pleura was stripped away until the posterior mediastinum was laid open for a considerable distance. Throughout the exposed area no infiltration was noted, and no lymph nodes were felt. The conclusion was reached that the entrance into the mediastinum was at a higher level and that a substantial collection of pus was not present. Further exploration of the mediastinum did not seem warranted. The remainder of the operation consisted in establishing better drainage at the site of the lateral thoracic sinus. The thick fibrous-tissue-lined tract, which was split open, ran a tortuous course upward and then mesially, apparently extrapleurally throughout the part exposed. The full course of the tract was not visualized.

The course was satisfactory, the temperature becoming normal by the fifth postoperative day. However, there was profuse drainage from, and some retention of pus in, the lateral thoracic wound. A roentgenogram after injection of iodized oil into the lateral thoracic wound demonstrated persistence of the communication between the lateral thoracic sinus and the mediastinum and some puddling in the mediastinum. A wider unroofing of the tract seemed warranted. The operation, performed Jan. 5, 1932, consisted of a more upward and mesial dissection of the lateral sinus tract together with the excision of additional ribs. A very extensive mobilization of scapula and excision of ribs would have been necessary to lay open the tract to its full limits. This appeared unjustified in view of the paucity of clinical manifestations referable to the sinus.

The postoperative course was again satisfactory. The temperature reached normal by the fourth postoperative day and remained so until discharge. The general condition of the child was correspondingly satisfactory. The posterior wound closed by mid-January, 1932. Discharge from the lateral sinus wound diminished progressively. On Feb. 19, 1932, the child left the hospital with only a small nondischarging sinus remaining.

Before discharge, on Feb. 11, iodized oil was injected into the small residual sinus. A narrow tract in the posterolateral part of the chest was seen to extend upward as far as the fourth rib posteriorly, where it stopped. A large amount of lipiodol was still to be seen in the mediastinum extending upward from the diaphragm almost to the base of the skull. However, communication had apparently ceased to exist between the lateral chest sinus and the mediastinal pocket.

Follow-up study showed that the lateral chest wound healed shortly after discharge and remained permanently closed except for a transitory reopening about one year later. Follow-up was continued for five and one-half years after discharge. The child remained entirely symptom-free throughout this time. Development and weight gain were normal. Roentgenograms on March 21, 1932, showed a large amount of lipiodol scattered throughout the mediastinum from the neck down to the diaphragm and some thickening of the pleura over the right lung (Fig. 4). On Oct. 16, 1934, the roentgenogram still showed a number of droplets of iodized oil scattered throughout the mediastinum from the cervical down to the dorsal region. Though there was no abnormality in the lungs or pleura, some widening of the mediastinum was still present (Fig. 5). On July 7, 1936, there was not only absence of abnormality in the lungs and pleura, but there was no longer any evidence of mediastinal widening.

Fig. 4.—B. B., March 21, 1932. Large amount of residual iodized oil in cervico-posterior mediastinal compartment from base of skull to diaphragm.

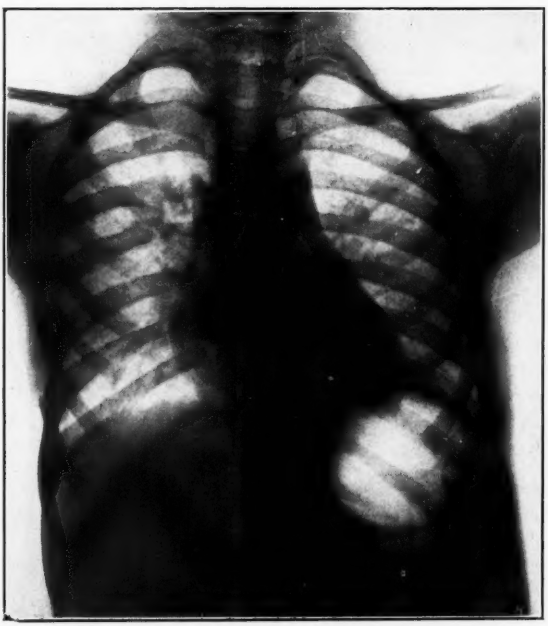

Fig. 5.—B. B., Oct. 16, 1934. Residual iodized oil droplets scattered through posterior mediastinum and neck. Only slight mediastinal widening now present.

## DISCUSSION

The roentgenographic demonstration of cervicomediastinal outline from the base of the skull to the diaphragm illustrates exquisitely the continuity between the two regions. It is interesting to note the persistence of iodized oil in the outlined cervicomediastinal compartment for approximately three years after its injection, thus demonstrating the well-defined closed anatomic space which is present.

The pathway of infection in this case appears to have been from the upper respiratory passages with secondary retropharyngeal abscess, descent in the fascial planes to the posterior mediastinum, and then, extension outward to an extrapleural location in the chest wall.

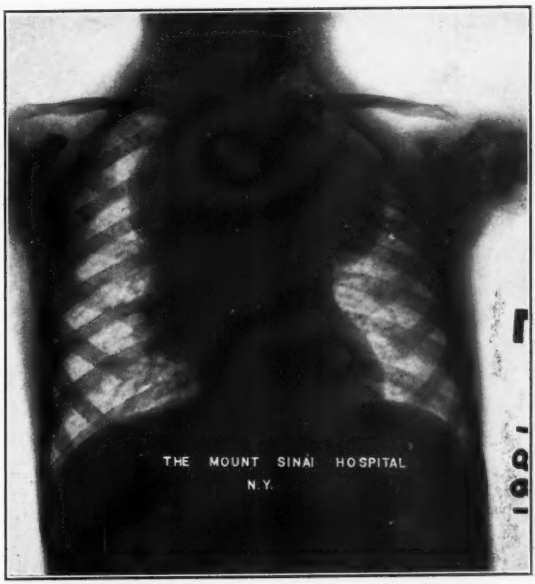


Fig. 6.—Case of 2½-year-old boy in which a large superior mediastinal abscess shadow extends almost to left lateral chest wall.

Descent of abscesses of the neck into the mediastinum along the fascial planes is not uncommon. In the literature, a full discussion of such descent of abscesses from the upper air passages to the mediastinum, including numerous case reports, is found in several articles by Glogau published between 1922 and 1928. Neuhof, in 1936, in an article based upon sixty-six cases of acute mediastinal infection, described this mode of descent in abscesses of the neck, secondary either to infections of the upper respiratory passages or to perforations of the cervical esophagus. One of the cases which is of special interest in connection with this report was that of a 2½-year-old boy, who, following an upper respiratory infection, developed a swelling at the right angle of the jaw, snoring, and dyspnea. These symptoms persisted despite the intraoral

incision of an abscess in the right side of the throat. On admission, a roentgenogram revealed a large superior mediastinal shadow extending from the sternum to the anterior border of the vertebrae and almost to the left lateral chest wall (Fig. 6). Anterior mediastinotomy was done, with cure. Postoperatively, iodized oil was injected into the anterior chest wound after a stomach tube had been placed in the esophagus for purposes of contrast. The injected oil was seen to course along the esophagus to the retrovisceral space, from which it ascended to the base of the skull and descended to the level of the eighth dorsal vertebra (Figs. 7 and 8). This case not only illustrates extension from the

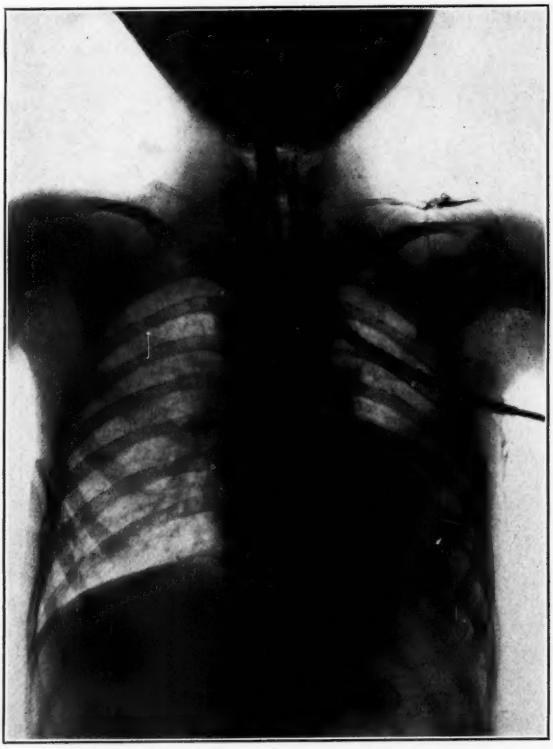

Fig. 7.—Same case as Fig. 6, after anterior mediastinotomy. Stomach tube in place. Iodized oil injected into anterior mediastinal sinus ascends to base of skull and descends to eighth dorsal vertebra. Large superior mediastinal shadow no longer seen.

neck to the posterior mediastinum, but also shows this extension as having occurred in the retrovisceral compartment. The pathway was demonstrable, even though the mediastinal abscess had expanded to a mass extending anteriorly to the sternum and laterally almost to the left lateral chest wall.

The other point illustrated by the reported case is that of extrapleural extension of mediastinal abscess. Extrapleural spread from the medi-

astinum is not as uncommon as one would suppose; nor is there any logical reason to assume that it should be rare despite the absence of any reference in the literature to this type of extension of acute pyogenic mediastinitis.* Although mediastinal infection can undoubtedly enter the pleura, the extrapleural plane offers a more natural cleavage surface, not necessitating the penetration of a tough parietal membrane.

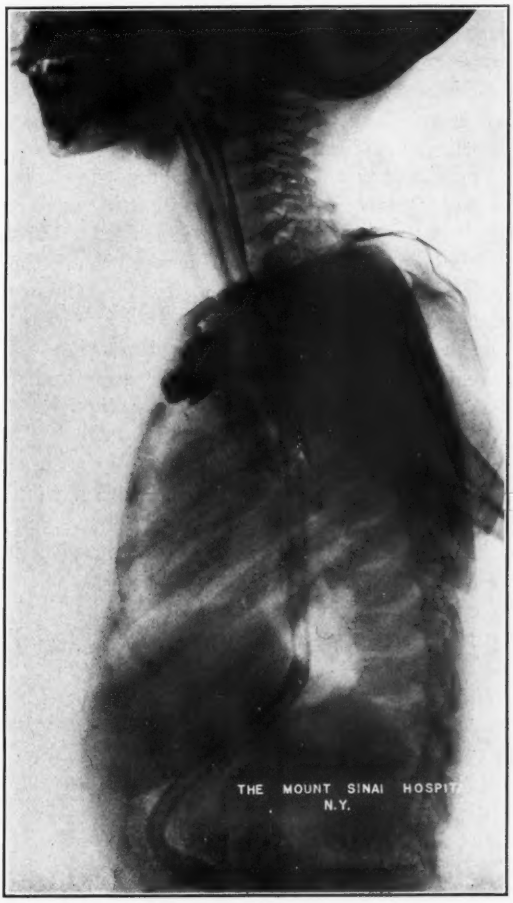


Fig. 8.—Same case as Fig. 6. Lateral view showing situation of iodized oil in retrovisceral space.

Usually, when parietal pleura is traversed, it is by an extremely intense infection, phlegmonous and diffuse in nature, resulting not in a localized pleural abscess, but in a pleural counterpart of the mediastinal process, usually bilateral. The larger mediastinal abscesses, seen by x-ray as a

*Ornstein and Ulmar, and Koch and Mayer include extrapleural spread as one of the possible types of extension of tuberculous paravertebral abscess secondary to thoracic Pott's disease.

marked widening of the mediastinum, involve not only a pushing apart of the surfaces of the pleura, but necessitate a degree of pleural stripping commensurate with the degree of widening. In extreme instances this is quite evident, the mediastinal abscess extending without pleural penetration out to the lateral parietes. One of the eventualities of such a process may be a chest wall lesion which overshadows the unlooked-for primary mediastinal component and which bears a very close clinical and roentgenographic resemblance to empyema thoracis. This may have been the situation in the reported case. The clinical significance of such a condition is obviously that drainage of such a collection of pus under the erroneous diagnosis of pleural empyema leaves inadequately cared for the primary mediastinal abscess.

Though not borne out by the operative findings, the possibility that the reported case was in reality a primary empyema with subsequent spread to the mediastinum must, of course, be considered. Several cases of this nature have been observed also. However, in all, the mediastinal component was merely a small localized pocket contiguous with a primary empyema. The extent of the mediastinal involvement in the reported case, and the persistence of this extensive cavity for so long after drainage, make it extremely likely that the mediastinal situation preceded the relatively small lateral chest wall collection.

## SUMMARY

1. The anatomy of the deep cervical fasciae with particular reference to their mediastinal continuations is reviewed.

2. A case is reported which offers a unique in vivo demonstration of cervicomediastinal continuity.

3. The concept of extrapleural extension of mediastinal abscess, also illustrated by the reported case, is briefly presented and discussed.

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# CERVICOMEDIASTINAL ABSCESS DUE TO NONPERFORATIVE TRAUMA TO THE ESOPHAGUS

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A SEQUENCE of events to which attention has not as yet been called is the formation of periesophageal cervicomediastinal abscess following nonperforative instrumental trauma to the esophagus. Such a condition was recently encountered in two cases.

CASE 1.—M. L. (Mount Sinai Hospital, No. 418253), a woman 38 years of age, was admitted Dec. 27, 1937, with a history of recurrent attacks of cramping epigastric pain radiating to both upper quadrants and shoulders since the age of 14 years. The attacks were accompanied by nausea and vomiting. She was yellow with several of the attacks during the first few years. Between attacks there was an almost constant sense of epigastric and substernal oppression, sometimes aggravated by eating. She often regurgitated her food immediately after eating. Her gall bladder and appendix had been removed six years before admission with no change in symptomatology. There was an episode of black stools, once, a year before admission. For one year there had also been complaints of amenorrhea and hot flushes. The preliminary work on the case was done in the Outpatient Department where a widemouthed diverticulum was found two to three inches above the cardia. Its appearance was peculiar, indicating possibly a large peptic ulcer of the esophagus.

Physical examination on admission was essentially negative. On Jan. 3, 1937, the identical lesion was again seen by fluoroscopy. Esophagoscopy was performed Jan. 6, revealing a diverticulum on the right posterior wall of the esophagus about one inch above the cardiac rugae. The procedure was executed smoothly and easily.

Following esophagoscopy there was dysphagia. The temperature rose to 102° the next day and to 103° the day after. The dysphagia was progressive, and severe pain developed in the thyroid region. A roentgenogram Jan. 8 showed a widening of the retrotracheal space with small irregular collections of air running up toward the base of the skull and down to the superior thoracic aperture within the infiltrated prevertebral tissues (Fig. 1). The trachea was displaced somewhat to the right, and there was a hazy shadow over the mesial aspect of the left lung apex and over the superior mediastinum. Clinically, there was fullness above the upper border of the sternum and marked tenderness with pronounced anterior displacement of the trachea indicated by inability to dip the finger into the retrosternal space.

Operation, consisting of cervical incision and drainage of a periesophageal and superior mediastinal abscess, was performed Jan. 8, forty-eight hours after esophagoscopy. Incision was made anterior to the left sternomastoid muscle. The abscess was foul. It extended completely across behind the pharynx and cervical esophagus, in front of the bodies of the several vertebrae. The left side was greater than the right. Necrotic tissue was present in laminated form, partly attached to the esophagus and to the prevertebral fascia. A curved instrument was passed into the superior thoracic aperture and about a dram of pus escaped from the posterior superior mediastinum. The limit of the abscess cavity was about the level of the aortic arch, although no effort was made to trace this accurately. Careful attempt

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was made to locate a site of perforation in the esophagus, *but none could be found.* A tube and gauze were placed into the posterior mediastinum, and the cervical incision was packed with gauze.

The postoperative course, on the whole, was uneventful. Two days after operation the temperature was 101.4° F. It then varied between 99.2° and 101°, until eight days after operation when it became normal, remaining so until discharge. Two days after operation, the packings were removed from the wound, and methylene blue was given by mouth. It did not appear in the cervical wound. A roentgenogram on this day showed the packing in the left supraclavicular wound, a stomach tube which had been inserted for feeding purposes in situ, and some increase in the widening of the superior mediastinal shadow. On January 12, four days after operation, methylene blue given by mouth did appear in the cervical wound. The dye

Fig. 1.—Case 1. Lateral roentgenogram of the neck showing widening of retrotracheal space with irregular collections of air (see arrow) running up it up to the base of the skull and down to the superior thoracic aperture.

still appeared in the wound after administration by mouth Jan. 18, but it no longer appeared after this date. The wound at this time was clean and granulating, and the general condition of the patient continued to improve. On January 21 the roentgenogram, aside from a slight thickening of the pleura over the left side of the upper mediastinum and the apex of the lung, showed no abnormality. The patient still complained of constant epigastric pain radiating across the abdomen to the left with no relation to meals, but swallowing was performed easily with only slight sticking. She was discharged February 1, symptom-free as far as the operative field was concerned.

Follow-up March 1, 1938, showed a well-healed wound. The patient complained of some pain of a vague nature in the back of the neck.

CASE 2.—B. D. (Mount Sinai Hospital, No. 419179), a woman, 43 years old, was admitted Jan. 18, 1938, with a history of rectal bleeding of one year's duration, during which time there had developed fatigue, dizzinesss, and headache. Diagnosis of hemorrhoids had been made, and they had been injected. However, at the second injection, two and one-half months before admission, profuse bleeding occurred. At this time, lower abdominal cramps and diarrhea of six to seven movements per day began to accompany the bloody stools. The stools not only were tarry but also contained bright red blood. Between episodes, the bowels were normal. The only other history was of a previouss admission in November, 1933, for incomplete abortion and fibroids.

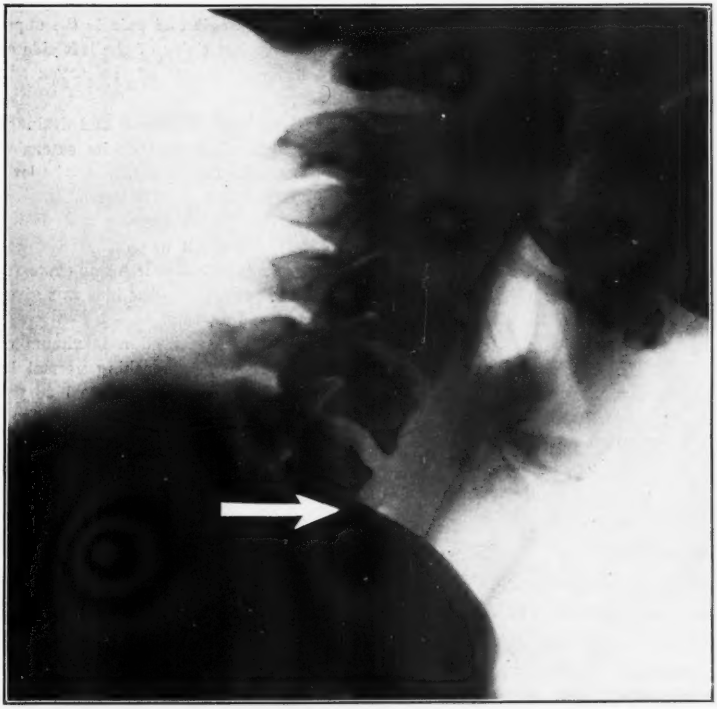

Fig. 2.—Case 2. Lateral roentgenogram of the neck showing slight widening of retrotracheal space which contains several small bubbles of gas (see arrow).

Examination on admission showed some impairment of pulmonary resonance at the apices and over the axillary and infraclavicular portion of the upper lobe of the left lung. The breath sounds were long in expiration over the same areas. There were showers of medium râles in the axillary region over the upper lobe of the left lung. A mass was felt in the right upper quadrant, fixed to the retroperitoneal tissues. The hemoglobin was 83 per cent (Sahli). Sigmoidoscopy and barium enema were negative. A roentgenogram of the chest showed an old fibrotic tuberculosis at the apex of the upper lobe of the right lung, extending to the third rib anteriorly. There were also seen many submiliary nodules which were mainly calcified. On

January 26 a gastrointestinal series showed a large polyp of the esophagus just above the cardiac opening. The stomach was negative. Esophagoscopy was performed January 27. No difficulty was encountered in the execution of the procedure. Thirty-five centimeters from the upper incisor teeth there was seen a yellowish, vascular mass about 1 cm. in diameter on the anterior esophageal wall. A specimen was taken for biopsy. Pathologic diagnosis was angiomatous fibroepithelial polyp.

The following day there were difficulty and pain on swallowing, the pain being situated in the upper dorsal region of the spine. The temperature was 99.8° F. There was no neck tenderness. The day after, January 29, the pain in the neck became severe and the dysphagia persisted. Tenderness could now be elicited in the anterior neck and beneath the left sternomastoid. The temperature had risen to 101.6°. A roentgenogram of the neck showed several small bubbles of gas in the retrotracheal space at the level of the sixth and seventh cervical vertebrae. There was slight widening of the retrotracheal space up to the level of the cricoid (Fig. 2). The chest showed no change. On January 29 there were dysphagia and pain in the upper dorsal region and the midline of the back. There were spasticity of the left side of the neck and tenderness on pressure over the left lateral aspect of the larynx and the adjacent structures. The trachea was pushed forward.

Operation, performed January 29, consisted of left cervical incision and drainage of a putrid periesophageal abscess and cervical mediastinotomy for its extension into the posterior superior mediastinum. The abscess was found just below the level of the larynx. It contained one dram of pus. Exudate was seen to extend upward over the prevertebral musculature and along the esophagus. Laterally and behind the esophagus, fresh fibrinous exudate was present. A small amount of pus was obtained from the posterior superior mediastinum. A meticulous search was made for a perforation in the esophagus, but none was found. Twice methylene blue was given by mouth at the operating table, but none appeared in the wound.

Postoperatively the patient did well. The temperature reached a maximum of 101.8° on the first postoperative day. It then gradually fell, reaching normal by the sixth postoperative day and remaining so until discharge. Methylene blue was given by mouth five times during the postoperative course, with the wound exposed and the packings out, but was never seen to appear in the cervical wound. At the time of discharge, February 16, the wound was practically healed.

## DISCUSSION

Acute periesophageal cervicomediastinal suppuration subsequent to esophageal perforation is quite common. These perforations are usually easily demonstrable at external operation, autopsy, or esophagoscopy as rather large, jagged tears marking the site of false passage. The ease with which the esophageal wall may be torn usually results in a substantial opening before the accident is noticed and the instrument withdrawn. Almost always, the esophagoscopist knows when false passage has been made.

In both the cases reported, esophagoscopy was executed easily and no postinstrumental difficulty was anticipated, yet periesophageal suppuration occurred in each. In the first case, no perforation was demonstrable at operation, despite excellent exposure and careful search. Methylene blue by mouth did not appear in the cervical wound until the fourth day after operation. Ordinarily, there is no difficulty in obtaining evidence of esophageal perforation in this manner.

The full significance of this first case was not accepted until the second was encountered. There was the inclination to feel that an actual perforation had taken place but could not be seen because of unusual position, and that the methylene blue did not come through because of some sort of valvular action of the flaps of the tear and the surrounding tissue. But in the second case, again despite smooth, easy esophagoscopy, a putrid abscess also formed around the pharynx and cervical and superior mediastinal esophagus. At the operation in this case, because of the discussion aroused by the previous one, an unusually thorough attempt was made to demonstrate an esophageal perforation. When this failed, methylene blue was given to the patient by mouth at the operating table twice, but methylene blue did not appear in the cervical wound. Subsequent to operation, methylene blue was given by mouth on five different occasions, with the packings out of the wound and the wound well exposed, but it was never seen to appear in the wound.

The sequence of events in these cases in the absence of any demonstrable perforation was probably as follows. Some degree of trauma to the esophagus took place during esophagoscopy, possibly with mucosal stripping and devitalization of the underlying esophageal wall by pressure. Here, as elsewhere, the devitalized tissue comprised a favorable nidus for anaerobic infection. A localized esophagitis in this area then occurred with spread taking place through it to the contiguous periesophageal tissue. It is interesting to compare this pathogenesis with that of peritonitis by seepage occurring from diseased, inflamed bowel without any actual perforation.

In the first case, it was not until this seepage of infection through the esophagus had already occurred that the process in the esophageal wall progressed to actual necrosis and perforation as shown by the time of appearance of methylene blue. In the second case, although a periesophageal suppuration was set up promptly, complete necrosis of the esophageal wall never occurred.

Lastly, it is of interest to note the presence of small loculations of air in the periesophageal tissue in the roentgenograms taken prior to operation. This finding, ordinarily considered pathognomonic of esophageal perforation, was apparently due here to the formation of gas by anaerobic bacteria.

## SUMMARY AND CONCLUSIONS

Two cases are reported of putrid periesophageal abscess extending into the mediastinum following trauma to the esophagus during esophagoscopy without any actual perforation of the viscus having taken place. The trauma was insignificant and might occur at any well-conducted esophagoscopy. Accordingly, these cases comprise

evidence that this complication should be watched for after any esophagoscopy, no matter how easily executed, if pain, dysphagia, or fever follows the passage of the instrument.

### ADDENDUM

Since the submission of the above report for publication, we have discovered three references in the literature to the production of periesophageal abscess by nonperforative trauma to the esophagus. Wietke (Ztschr. f. Hals-, Nasen- u. Ohrenh. **28**: 58, 1930) reported two cases of mediastinal infection following esophagoscopy. Both died after cervical mediastinotomy, and autopsy showed in each a laceration of the mucosa of the esophagus without any demonstrable perforation. Churchill (Surg. Gynec. & Obst. **60**: 417, 1935), although he included no case reports, mentioned that periesophageal infection might originate in an abrasion of the esophageal wall without actual perforation. Phillips (J. A. M. A. **111**: 998, 1938) possibly alluded to this mechanism by stating that a virulent infection with a minimum of trauma to the esophagus might set up active mediastinitis.

# PNEUMONECTOMY FOR MALIGNANT AND SUPPURATIVE DISEASE OF THE LUNG

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THE accomplishment of pneumonectomy in man will stand out as one of the great surgical contributions of the present decade. In fact, in a period of seven years, not only has the first successful lung resection been recorded, but considerable experience with the operation has been gained in various thoracic clinics; and we have seen a renewed interest in pulmonary cancer and other diseases lending themselves to treatment by excision. Although data concerning many phases of the subject is rapidly accumulating, the operation is in no way standardized, nor has its relative position in the treatment program of pulmonary diseases been determined. The ultimate usefulness of lung resection in the treatment of cancer will depend, for the most part, upon two factors: first, early discovery of the lesion; and second, a reasonably low operative mortality. For a solution of the first problem, we must rely to a great extent on the awareness of the general medical profession and upon the diagnostic skill of the internist, roentgenologist, and bronchoscopist. For an answer to the second problem, we must look to the accumulative experience of thoracic surgeons. It has been predicted by some that pneumonectomy will continue to be a dramatic "stunt" operation for the rare patient in whom cancer is discovered before extension beyond the lung has occurred. Also, it has been pointed out that the odds are overwhelmingly against a technical success due to the magnitude of such a procedure in patients of the cancer age group. Experience to date does not justify this pessimism. Results already indicate that a patient with a primary cancer of the lung has as good a chance, or possibly a better chance, than a patient with cancer of the stomach which requires total gastrectomy for its eradication. Results in the treatment of eight patients by the total removal of the lung for cancer or suppuration were presented by the author[39] before the American Association for Thoracic Surgery in 1935. In this group, there were five operative successes. During the past three years, pneumonectomy has been performed in fourteen additional patients, with success in twelve, bringing the total experience up to twenty-two operations, of which seventeen were successful. It is the purpose of this communication to present the results of this added experience and to append a summary of all recorded cases as found in the literature from the first operation up to the present time.

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TABLE I

COLLECTED CASES OF PNEUMONECTOMY FOR BENIGN LESIONS

| CASE NUMBER | AUTHOR | OPERATIVE RECOVERY, SURVIVED 2 MONTHS OR MORE | YEAR OF OPERATION | DIAGNOSIS | AGE | SEX | SIDE OF OPERATION | APPROACH | | TREATMENT OF HILUM | | | DRAINAGE (P, PACK; T, TUBE) | BRONCHIAL FISTULA | CAUSE OF DEATH | SURVIVAL AFTER OPERATION | METASTASES FOUND LATER | SUBSEQUENT THORACOPLASTY | PRESENT STATE OF HEALTH | DURATION OF SURVIVAL AT LAST REPORT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ANTERIOR | POSTERIOR | MASS LIGATION | INDIVIDUAL LIGATION | SUTURE MATERIAL (C, CATGUT; S, SILK) | | | | | | | | |
| 1 | Lilienthal | – | 1919 | Bronchiectatic lung abscess | 12 | F | R | – | + | + | – | ? | P | – | Edema of lung | 6 hr. | – | – | | |
| 2 | Lilienthal | – | 1920 | Suppurative pneumonitis | 8 | F | L | – | + | + | – | S | – | + | Hemorrhage | 13 days | – | – | | |
| 3 | Nissen | + | 1931 | Bronchiectasis | 12 | F | L | – | + | + | – | † | P | + | | | – | – | ? | ? |
| 4 | Haight | + | 1932 | Bronchiectasis | 13 | F | L | + | + | + | – | S | P | + | | | – | Prelim. | Fair | 6½ mo. |
| 5 | Alexander | – | 1933 | Multiple abscesses | ? | ? | R | – | + | + | ? | ? | P | ? | ? | 8 days | – | Prelim. | | |
| 6 | Alexander | + | 1933 | Bronchiectasis | ? | ? | L | – | + | ? | ? | ? | P | ? | | | – | Prelim. | ? | ? |
| 7 | Archibald | – | 1934 | Tuberculosis; bronchiectasis | ? | ? | R | + | + | + | – | S | ? | ? | Shock | 2 hr. | – | Prelim. | | |
| 8 | Mason | + | 1934 | Healed empyema; bronchiectasis | 13 | F | L | + | + | + | – | S | P | + | | | – | + | Well | 18 mo. |

See footnotes at end of table.

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | Dewey* | – | 1934 | ? | ? | ? | ? | – | + | ? | ? | ? | ? | ? | ? | 24 hr. | – | – | | |
| 10 | Mason | + | 1934 | Bronchiectasis | 18 | M | R | + | + | + | – | S | P | + | | | – | + | Fair | 2 yr. |
| 11 | Edwards | + | 1935 | Bronchiectasis and lung abscess | 7 | M | L | – | + | ? | ? | C | T | + | | | – | – | Excellent | 9 mo. |
| 12 | Roberts | + | 1935 | Bronchiectasis | 5 | M | L | – | + | + | – | C | T | + | | | – | – | Excellent | 2 yr. |
| 13 | Beye | + | 1935 | Cavernous tuberculosis | 45 | F | L | – | + | + | – | C | T | + | | | – | Prelim. | Excellent | ? |
| 14 | Mason | – | 1935 | Bronchiectasis | 7 | M | L | + | + | + | – | S | P | ? | Gangrene after first stage | 6 days | – | – | | |
| 15 | Edwards | + | 1935 | Bronchiectasis | 10 | M | R | – | + | ? | ? | C | T | + | | | – | ? | Fair | Several wk. |
| 16 | Walker | + | 1935 | Bronchiectasis | 7 | M | L | ? | ? | + | – | ? | T | – | | | – | – | Good | ? |
| 17 | Mason | + | 1935 | Congenital bronchiectasis | 10 | F | L | – | + | ? | ? | ? | T | – | | | – | – | Good | 1 yr. |
| 18 | Gale, Keely, and Coon | + | 1935 | Infected congenital cystic disease | 29 | M | L | ? | ? | ? | ? | ? | T | ? | | | – | Prelim. | Good | 4 mo. |
| 19 | Mason | – | 1935 | Bronchiectasis | 11 | M | L | – | + | – | ? | ? | T | ? | Shock and vagus injury(?) | 14 hr. | – | – | | |
| 20 | Churchill | + | 1935 | Bronchiectasis | 16 | F | L | – | + | – | + | C | T | + | | | – | + | Excellent | ? |
| 21 | Crafoord* | + | 1935 | Tuberculosis; bronchiectasis | 36 | F | L | – | + | – | + | S | T | – | | | – | – | Well | 3 yr. |
| 22 | Churchill* | – | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | – | ? | | |
| 23 | Mason* | + | 1936 | Bronchiectasis | 8 | M | L | – | + | – | ? | ? | T | ? | | | – | ? | Excellent | ? |

See footnotes at end of table.

TABLE I—CONT'D

| CASE NUMBER | AUTHOR | OPERATIVE RECOVERY, SURVIVED 2 MONTHS OR MORE | YEAR OF OPERATION | DIAGNOSIS | AGE | SEX | SIDE OF OPERATION | APPROACH | | TREATMENT OF HILUM | | | DRAINAGE (P, PACK; T, TUBE) | BRONCHIAL FISTULA | CAUSE OF DEATH | SURVIVAL AFTER OPERATION | METASTASES FOUND LATER | SUBSEQUENT THORACOPLASTY | PRESENT STATE OF HEALTH | DURATION OF SURVIVAL AT LAST REPORT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ANTERIOR | POSTERIOR | MASS LIGATION | INDIVIDUAL LIGATION | SUTURE MATERIAL (C, CATGUT; S, SILK) | | | | | | | | |
| 24 | Graham* | + | 1936 | ? | 5 | F | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | - | ? | ? | ? |
| 25 | Graham* | + | 1936 | ? | 7 | F | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | - | ? | ? | ? |
| 26 | Lanman | + | 1936 | Bronchiectasis | 6 | M | L | - | + | + | - | S | T | - | | | - | | Good | 1 yr., 4 mo. |
| 27 | Lanman | + | 1936 | Bronchiectasis | 9 | M | L | - | + | + | - | S | T | - | | | - | Prelim. | Excellent | 1½ yr. |
| 28 | Lanman | - | 1936 | Bronchiectasis | 9 | F | L | - | + | | | | | | Sudden death on table. Cause unknown | | | | | |
| 29 | Lindskog | + | 1936 | Tuberculosis; bronchiectasis | 16 | F | L | - | + | + | - | C | T | + | | | - | - | Dying; T.B. opposite side | 1 yr. |
| 30 | Arce* | + | 1936 | Congenital bronchiectasis | 12 | M | L | + | - | + | - | S | P | ? | | | - | At operation | Good; empyema | 90 days |

See footnotes at end of table.

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | Arce* | + | 1936 | Tuberculosis | 25 | F | ? | - | + | + | - | ? | P | ? | | | - | At operation | ? | ? |
| 32 | Arce* | + | 1936 | Congenital cystic disease | 9 | M | ? | - | + | + | - | ? | P | ? | | | - | At operation | ? | ? |
| 33 | Crafoord* | - | 1936 | Bronchiectasis | 19 | F | L | - | + | - | + | S | - | + | Mediastinitis, pleuritis, pericarditis, and sepsis | 3 wk. | - | - | | |
| 34 | Freedlander | + | 1936 | Chronic lung abscess | 54 | M | R | + | - | - | + | C | ? | + | | | - | - | Excellent | 1 yr. |
| 35 | Freedlander | + | 1936 | Multiple abscesses and bronchiectasis | 40 | M | R | + | - | - | + | C | - | + | | | - | - | Good | 4½ mo. |
| 36 | Freedlander | - | 1936 | Bronchiectasis | 43 | F | R | - | + | + | - | C | T | + | Empyema; probable mediastinitis | 22 days | - | - | | |
| 37 | Burnett | + | 1936 | Abscess and bronchiectasis | 8 | F | L | - | + | + | - | S | T | - | | | - | - | Excellent | 3 mo. |
| 38 | Rienhoff | + | Reported 1936 | Tuberculosis | ? | ? | ? | + | - | - | + | S | - | - | | | - | ? | ? | ? |
| 39 | Rienhoff | + | Reported 1936 | Tuberculosis | ? | ? | ? | + | - | - | + | S | - | - | Pulmonary tuberculosis | 3 mo. | - | - | | |

See footnotes at end of table.

TABLE I—CONT'D

| CASE NUMBER | AUTHOR | OPERATIVE RECOVERY, SURVIVED 2 MONTHS OR MORE | YEAR OF OPERATION | DIAGNOSIS | AGE | SEX | SIDE OF OPERATION | APPROACH | | TREATMENT OF HILUM | | | DRAINAGE (P, PACK; T, TUBE) | BRONCHIAL FISTULA | CAUSE OF DEATH | SURVIVAL AFTER OPERATION | METASTASES FOUND LATER | SUBSEQUENT THORACOPLASTY | PRESENT STATE OF HEALTH | DURATION OF SURVIVAL AT LAST REPORT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ANTERIOR | POSTERIOR | MASS LIGATION | INDIVIDUAL LIGATION | SUTURE MATERIAL (C, CATGUT; S, SILK) | | | | | | | | |
| 40 | Crafoord* | + | 1937 | Tuberculosis and bronchiectasis | 27 | F | R | - | + | - | + | S | - | - | | | - | - | Well | 10 mo. |
| 41 | Roberts* | + | 1937 | Congenital cystic disease | 2 | M | R | - | + | + | - | C | T | + | | | - | - | Well | 6 mo. |
| 42 | Crafoord* | + | 1938 | Tuberculosis and bronchiectasis | 30 | F | L | - | + | - | + | S | T | - | | | - | - | Well | 2 mo. |
| 43 | Edwards* | + | No details except report of two deaths and three recoveries | | | | | | | | | | | | | | | | | |
| 44 | Edwards* | + | | | | | | | | | | | | | | | | | | |
| 45 | Edwards* | + | | | | | | | | | | | | | | | | | | |
| 46 | Edwards* | - | | | | | | | | | | | | | | | | | | |
| 47 | Edwards* | - | | | | | | | | | | | | | | | | | | |
| 48 | Holst* | + | No details. Recovery | | | | | | | | | | | | | | | | | |

*Information obtained from monograph by C. Crafoord, "On the Technique of Pneumonectomy in Man," from Surgical Clinic II of the Sabbatsberg Hospital, Stockholm, 1938.

†Rubber tube and silk.

## HISTORICAL DATA

A period of thirty years elapsed between the experimental demonstration of Gluck (1881) that animals survived pneumonectomy and the time when the operation was attempted in man by Kümmel (1910). Unfortunately, the termination was fatal. In the next twenty years, there are records in the literature of five other attempts to resect a human lung. The first successful attempt at what might be called a total pneumonectomy was made by Nissen[36] in 1931. In a child 12 years of age who had extensive total bronchiectasis of the left lung, he ligated the entire hilum with a rubber and silk ligature in two stages with the idea of having the lung slough out. This occurred later. A similar procedure was successfully carried out by Haight[23] in November, 1932, also for total bronchiectasis in a child of 13 years and also in two stages. The first successful one-stage total pneumonectomy, however, and the first successful total pneumonectomy for carcinoma, was performed by Graham and Singer[21] in April, 1933, on a man of 48 years. This also was the left lung. In the same year Rienhoff[42] successfully removed the left lung from a child 3½ years old and from a woman 24 years old. Also, in 1933, Overholt[38] performed the first successful resection of the right lung, this for carcinoma in a woman of 35 years. Since these early reports of successful cases, the list of attempted operations of this type has grown steadily. For the most part, reports have been sporadic. A limited series of cases has been reported, eight by Overholt,[39] and sixteen by Crafoord.[9] The technique of pneumonectomy has been given particular consideration by Archibald,[4] Rienhoff,[43] and Overholt.[41] Edwards[14] has recently discussed the subject of lung tumors with reference to surgical treatment, and monographs on the subject of pneumonectomy have been prepared by Bonnoit and Monod,[6] Galarce,[18] and Crafoord.[9] In the monograph by Crafoord published in May, 1938, there is included an exhaustive summary of all reported cases. The summary lists separately those operations done for benign lesions and those carried out for malignant lesions. By using Crafoord's data and adding recent case reports, a record of 110 operations can be found, not including the author's 22 cases. This material has been assembled in Tables I, II, and III. For purposes of studying mortality rates, the first six cases, which were all fatal, may be excluded with fairness. In summarizing the total experience in the collected cases of pneumonectomy from the first successful one (Nissen, 1931) up to the present, there is a record of the following:

| | DIAGNOSIS | NUMBER OF CASES | OPERATIVE MORTALITY | PER CENT |
|---|---|---|---|---|
| Collected cases | Benign lesions | 46 | 11 | 24 |
| | Malignant lesions | 58 | 38 | 65.5 |
| | | 104 | 49 | 47 |
| Overholt | Benign lesions | 7 | 0 | 0 |
| | Malignant lesions | 15 | 5 | 33.3 |
| | | 22 | 5 | 22 |

TABLE II

COLLECTED CASES OF PNEUMONECTOMY FOR MALIGNANT LESIONS

| CASE NUMBER | AUTHOR | OPERATIVE RECOVERY, SURVIVED 2 MONTHS OR MORE | YEAR OF OPERATION | DIAGNOSIS | AGE | SEX | SIDE OF OPERATION | APPROACH | | TREATMENT OF HILUM | | | DRAINAGE (P, PACK; T, TUBE) | BRONCHIAL FISTULA | CAUSE OF DEATH | SURVIVAL AFTER OPERATION | METASTASES FOUND LATER | SUBSEQUENT THORACOPLASTY | PRESENT STATE OF HEALTH | DURATION OF SURVIVAL AT LAST REPORT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ANTERIOR | POSTERIOR | MASS LIGATION | INDIVIDUAL LIGATION | SUTURE MATERIAL (C, CATGUT; S, SILK) | | | | | | | | |
| 1 | Kümmel | - | 1910 | Carcinoma | 48 | M | R | - | + | + | - | † | P | - | Pneumonitis and cardiac failure | 6 days | Pleural | At operation | | |
| 2 | Meyer | - | 1920 | Lymphosarcoma and bronchiectasis | 5 | M | R | - | + | + | - | C | T | - | Pulmonary edema and cardiac failure | 10 hr. | - | At operation | | |
| 3 | Hinz | - | 1922 | Carcinoma | 56 | F | L | - | + | - | + | ? | ? | - | Emphysema of lung and mediastinum and cardiac failure | 3 days | - | At operation | | |

See footnotes at end of table.

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | Archibald | – | 1931 | Carcinoma | 35 | M | L | + | + | – | + | C, Sil. wire | T | – | Streptococcus septicemia | 4 days | – | – | | |
| 5 | Bigger* | – | 1932 | Carcinoma | 14 | M | ? | – | + | – | + | C | T | – | Pneumonitis and pericarditis | 5 wk. | Mediastinal glands | – | | |
| 6 | Ivanissevich and Ferrari | – | 1932 | Carcinoma | 45 | M | L | + | – | – | + | ? | – | – | Pneumonitis and cardiac failure | 8 days | ? | – | | |
| 7 | Lilienthal | – | 1933 | Metastatic sarcoma | 34 | F | L | – | + | + | – | C | – | – | Pneumonitis | 4 days | Primary sarcoma of uterus | – | | |
| 8 | Graham and Singer | + | 1933 | Carcinoma | 48 | M | L | – | + | + | – | C | T | – | | | – | At operation | Well | 2 yr. |
| 9 | Archibald | + | 1933 | Carcinoma | 31 | M | L | + | – | – | + | C, Sil. wire | T | – | Pleural metastases | 9 mo. | Pleural | – | | |
| 10 | Rienhoff | + | 1933 | Sarcoma | 3½ | F | L | + | – | – | + | S & C | – | – | | 3½ yr. | ? | – | Drowned | |
| 11 | Rienhoff | + | 1933 | Carcinoma | 24 | F | L | + | – | – | + | S | – | + | | | – | – | Well | 6 mo., 1934 |
| 12 | Freedlander | – | 1933 | Carcinoma | 44 | M | L | – | + | + | – | ? | ? | ? | Empyema and bronchopneumonia | 22 days | – | + at 21 days | | |
| 13 | Alexander | – | 1933 | Carcinoma | ? | M | L | ? | ? | ? | ? | ? | ? | ? | Cardiac failure | 32 days | – | – | | |

See footnotes at end of table.

TABLE II—CONT'D

| CASE NUMBER | AUTHOR | OPERATIVE RECOVERY, SURVIVED 2 MONTHS OR MORE | YEAR OF OPERATION | DIAGNOSIS | AGE | SEX | SIDE OF OPERATION | APPROACH | | TREATMENT OF HILUM | | | DRAINAGE (P, PACK; T, TUBE) | BRONCHIAL FISTULA | CAUSE OF DEATH | SURVIVAL AFTER OPERATION | METASTASES FOUND LATER | SUBSEQUENT THORACOPLASTY | PRESENT STATE OF HEALTH | DURATION OF SURVIVAL AT LAST REPORT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ANTERIOR | POSTERIOR | MASS LIGATION | INDIVIDUAL LIGATION | SUTURE MATERIAL (C, CATGUT; S, SILK) | | | | | | | | |
| 14 | Edwards | – | 1934 | Carcinoma | ? | M | R | – | + | + | – | C | T | ? | Pleural infection; mediastinitis | 16 days | Liver | At operation | | |
| 15 | Edwards | – | 1934 | Carcinoma | ? | M | R | – | + | + | – | C | T | ? | Cardiac failure | 3 days | ? | – | | |
| 16 | Flick and Gibbon | + | 1934 | Carcinoma | 46 | M | L | + | – | – | + | C | – | – | Hemorrhage and local recurrence | 8½ mo. | At stump | 2 mo. + | | |
| 17 | Crafoord | – | 1934 | Carcinoma | 26 | F | R | – | + | – | + | S & C | T | – | Hemorrhage from chest wall | 12 hr. | – | – | | |
| 18 | Churchill* | – | 1934 | Carcinoma | ? | ? | 2 R and 1 L | ? | ? | ? | ? | ? | ? | ? | Perforation of duodenal ulcer | 10 days | – | – | | |
| 19 | Churchill* | + | 1934 | Carcinoma | ? | ? | | ? | ? | ? | ? | ? | ? | ? | Widespread metastases | 2½ mo. | [illegible] | – | | |
| 20 | Churchill* | + | 1934 | Carcinoma | ? | ? | | ? | ? | ? | ? | ? | ? | ? | Metastases | ? | + | – | | |

See footnotes at end of table.

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | Freedlander | – | 1934 | Carcinoma | 45 | M | R | – | + | + | – | ? | ? | ? | Pneumonia and empyema | 1 mo. | Lungs, liver, and mediastinum | – | | |
| 22 | Lyle | + | 1935 | Carcinoma | 61 | F | R | + | – | – | + | S | – | + | | | – | ? | Well; draining sinus | 2 mo., 1935 |
| 23 | Lambret* | – | 1935 | Carcinoma | 59 | M | L | + | – | – | + | S | T | – | Shock and hemorrhage | 18 hr. | – | – | | |
| 24 | Frissel and Knox* | – | 1935 | Carcinoma | 42 | M | L | ? | ? | ? | ? | ? | ? | – | Shock after second stage | 26 hr. | Glands | – | | |
| 25 | Crafoord* | – | 1935 | Carcinoma | 45 | M | L | – | + | – | + | C | T | + | Lung abscess, empyema | 7 wk. | Liver and opposite lung | – | | |
| 26 | Santy et al.* | – | 1935 | Carcinoma | 45 | M | ? | + | – | + | – | ? | ? | – | Empyema and pneumonitis | 4 days | + | – | | |
| 27 | Duval and Monod | – | 1935 | Carcinoma | 59 | M | R | + | – | ? | ? | ? | ? | – | Shock at end of operation | 1 hr. | ? | – | | |
| 28 | Crafoord* | – | 1936 | Carcinoma | 52 | M | R | - | + | – | + | C | T | – | Carotid embolism | 30 hr. | – | – | | |
| 29 | Crafoord* | + | 1936 | Malignant mixed tumor | 46 | M | L | - | + | – | + | C & S | T | + | | | – | + | Well; persistent fistula | 2 yr., 1938 |
| 30 | Crafoord* | – | 1936 | Carcinoma | 44 | M | R | – | + | – | + | C & S | T | – | Pleural infection | 7 days | Mediastinum | – | | |
| 31 | Freedlander | + | 1936 | Carcinoma | 40 | F | R | + | – | – | + | S | – | – | | | – | – | Excellent | 1 yr., 1937 |

See footnotes at end of table.

TABLE II—CONT'D

| CASE NUMBER | AUTHOR | OPERATIVE RECOVERY, SURVIVED 2 MONTHS OR MORE | YEAR OF OPERATION | DIAGNOSIS | AGE | SEX | SIDE OF OPERATION | APPROACH | | TREATMENT OF HILUM | | | DRAINAGE (P, PACK; T, TUBE) | BRONCHIAL FISTULA | CAUSE OF DEATH | SURVIVAL AFTER OPERATION | METASTASES FOUND LATER | SUBSEQUENT THORACOPLASTY | PRESENT STATE OF HEALTH | DURATION OF SURVIVAL AT LAST REPORT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ANTERIOR | POSTERIOR | MASS LIGATION | INDIVIDUAL LIGATION | SUTURE MATERIAL (C, CATGUT; S, SILK) | | | | | | | | |
| 32 | Crafoord* | – | 1936 | Carcinoma | 50 | M | R | – | + | – | + | C & S | – | – | Pulmonary embolism | 3 days | – | – | | |
| 33 | Freedlander | – | 1936 | Carcinoma | 47 | M | L | + | – | – | + | S | – | – | Pericarditis, mediastinitis, and empyema | 11 days | – | – | | |
| 34 | Freedlander | – | 1937 | Carcinoma | 39 | M | R | + | – | – | + | S | T | – | Hemorrhage from pulmonary vein | 18 days | Mediastinum | – | | |
| 35 | Crafoord* | – | 1937 | Carcinoma | 47 | F | L | – | + | – | + | C & S | – | – | Pneumonitis and acute pulmonary edema | 11 days | – | – | | |
| 36 | Crafoord* | + | 1937 | Carcinoma | 50 | M | L | – | + | – | + | C & S | – | – | Pneumonitis and cardiac failure | 5 mo. | – | – | | |
| 37 | Crafoord* | – | 1937 | Carcinoma | 63 | M | L | – | + | – | + | C & S | – | – | Pulmonary edema | 36 hr. | Mediastinum | – | | |

See footnotes at end of table.

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 | Crafoord* | + | 1937 | Carcinoma | 50 | M | R | − | + | − | + | C & S | − | − | | | − | − | Excellent | 4 mo., 1938 |
| 39 | Crafoord* | + | 1938 | Carcinoma | 50 | M | L | − | + | − | + | C & S | − | − | | | − | − | Good | 2 mo., 1938 |
| 40 | Crafoord* | − | 1938 | Carcinoma | 50 | M | R | − | + | − | + | S & C | − | − | Pneumonitis and atelectasis | 3 days | Mediastinum | − | | |
| 41 | Rienhoff | − | Reported in 1936 | Carcinoma | ? | ? | | + | − | − | + | S | − | ? | 1 of bronchopneumonia | 5 days | ? | − | | |
| 42 | Rienhoff | + | | Carcinoma | ? | ? | | + | − | − | + | S | − | ? | 1 of metastases | 6 mo. | + | − | | |
| 43 | Rienhoff | − | | Carcinoma | ? | ? | 3 R and 3 L | + | − | − | + | S | − | ? | 1 of pulmonary embolism | 6 wk. | ? | − | | |
| 44 | Rienhoff | + | | Carcinoma | ? | ? | | + | − | − | + | S | − | − | | | ? | − | ? Alive in 1936 | ? |
| 45 | Rienhoff | + | | Carcinoma | ? | ? | | + | − | − | + | S | − | − | | | ? | − | ? | ? |
| 46 | Rienhoff | + | | Carcinoma | ? | ? | | + | − | − | + | S | − | − | | | ? | − | ? | ? |
| 47 | Haight* | + | ? | Carcinoma | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | | | ? | ? | ? | ? |
| 48 | Graham | − | ? | Carcinoma | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | Pneumonia | 3 wk. | − | − | | |
| 49 | Graham | − | ? | Carcinoma | ? | ? | ? | ? | ? | ? | ? | ? | ? | + | Aspiration pneumonia | 3½ wk. | − | − | | |
| 50 | Graham | + | ? | Carcinoma | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | Cerebral metastases | ? | + | ? | | |

See footnotes at end of table.

TABLE II—CONT'D

| CASE NUMBER | AUTHOR | OPERATIVE RECOVERY, SURVIVED 2 MONTHS OR MORE | YEAR OF OPERATION | DIAGNOSIS | AGE | SEX | SIDE OF OPERATION | APPROACH | | TREATMENT OF HILUM | | | DRAINAGE (P, PACK; T, TUBE) | BRONCHIAL FISTULA | CAUSE OF DEATH | SURVIVAL AFTER OPERATION | METASTASES FOUND LATER | SUBSEQUENT THORACOPLASTY | PRESENT STATE OF HEALTH | DURATION OF SURVIVAL AT LAST REPORT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ANTERIOR | POSTERIOR | MASS LIGATION | INDIVIDUAL LIGATION | SUTURE MATERIAL (C, CATGUT; S, SILK) | | | | | | | | |
| 51 | Frissel and Knox* | + | ? | Carcinoma | 64 | F | R | ? | ? | ? | ? | ? | ? | ? | Metastases | 6 mo. | + | - | | |
| 52 | Arce* | - | ? | Carcinoma | ? | ? | L | ? | ? | ? | ? | ? | ? | - | Cardiac failure | 8 hr. | - | - | | |
| 53 | Arce* | - | ? | Carcinoma | ? | ? | ? | ? | ? | ? | ? | ? | ? | - | Cardiac failure | 2 days | - | - | | |
| 54 | Holst* | - | ? | Carcinoma | 52 | F | ? | ? | ? | ? | ? | ? | ? | ? | Pleural infection | 8 days | ? | - | | |
| 55 | Ivanissevich* | - | ? | Carcinoma | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | Cardiac failure | 8 days | - | - | | |
| 56 | Edwards* | No details. Three survived operation; one died. | | | | | | | | | | | | | | | | | | |
| 57 | Edwards* | | | | | | | | | | | | | | | | | | | |
| 58 | Edwards* | | | | | | | | | | | | | | | | | | | |
| 59 | Edwards* | | | | | | | | | | | | | | | | | | | |
| 60 | Churchill* | No details. All fatal. | | | | | | | | | | | | | | | | | | |
| 61 | Churchill* | | | | | | | | | | | | | | | | | | | |
| 62 | Churchill* | | | | | | | | | | | | | | | | | | | |

*Information obtained from monograph by C. Crafoord, "On the Technique of Pneumonectomy in Man," from Surgical Clinic II of the Sabbatsberg Hospital, Stockholm, 1938.

†Forceps left on pedicle.

## TYPE OF PATIENT SELECTED FOR PNEUMONECTOMY

The indication for pneumonectomy in seven of the twenty-two patients in this series was unilateral suppuration with or without benign bronchial obstruction. The process in all patients was totally incapacitating; and in four patients, it was immediately threatening life. In these four patients, total resection of the lung was necessitated by the extent of the disease. In two patients, a large solitary lung abscess involved both upper and lower lobes and, upon thoracic exploration, presented the picture of a large peripheral primary tumor. In both of these patients, it was technically impossible to resect the lesion without removing the lung in its entirety. The strong suspicion of malignancy also made total resection the safest procedure for the patient. An obstructing adenoma of the left main stem bronchus was the indication in one patient. Bronchial stenosis with recurring pneumonia in a patient with arrested pulmonary tuberculosis, in whom a complete thoracoplasty had been previously performed, was another indication. Fortunately, all seven patients operated upon for benign lesions survived the operation.

The indication for pneumonectomy in the remaining fifteen patients was primary malignancy of the lung. This group represents approximately one-fourth of all verified cases of primary malignancy of the lung studied by the author in the past five years. During this time, investigation of eighty-one patients led to a presumptive diagnosis of primary lung cancer. In sixty-four patients, tissue was obtained to establish the diagnosis definitely. Upon the basis of the outcome of the original clinical study, the following disposition was made:

| | | |
|---|---|---|
| 1. Primary carcinoma suspected, but tissue not obtainable for histologic verification | | 17 |
| (These cases were rejected for thoracic exploration because of age, poor general condition, or obvious metastatic extension.) | | |
| 2. Primary carcinoma verified by histologic examination | | 64 |
| a. First discovered at post-mortem | 5 | |
| b. Rejected on account of poor general condition | 3 | |
| c. Rejected on account of clinical evidence of metastasis | 22 | |
| d. Rejected on account of mediastinal invasion as discovered by thoracic exploration | 15 | |
| e. Bronchoscopic fulguration | 1 | |
| f. Lobectomy | 3 | |
| g. Pneumonectomy | 15 | |
| | 64 | 81 |

## EARLY SYMPTOMS

The most frequent early symptoms which called the attention of the patient or of his physician to a possible chest lesion, which led to further investigation and to a final diagnosis of primary pulmonary malignancy, were as follows:

1. Cough, of a chronic nature, was present in 82 per cent of the patients. It was the most consistent "first symptom," as 60 per cent

of the patients dated their illness with the onset of cough. The majority complained of an irritative, dry, hacking type of cough early in the history. If the cough became productive at an early stage, clear mucus was the usual type of sputum. Later, many patients raised purulent material similar to that seen in bronchiectasis or lung abscess, this development being due to an associated infection which frequently occurs.

2. Chest discomfort, or chest pain, was noted by 40 per cent of the patients. A sense of constriction or heaviness in the chest was not an unusual early symptom in those patients having a stem bronchus carcinoma with bronchial obstruction and atelectasis of a lobe or the entire lung. Severe intercostal neuralgia was present in some cases found to have a tumor situated peripherally which had infiltrated the thoracic wall. Severe chest pain should not be considered an early symptom.

3. Blood-streaked sputum was an early symptom in 40 per cent of the patients. Its appearance was usually intermittent. In many instances, the streaking was so slight that the patients discounted any significance to its presence. Massive pulmonary hemorrhages never occurred as an early manifestation of the disease but did occur as a late symptom.

4. Gastrointestinal symptoms were present early in 10 per cent of the patients and were predominant symptoms in 5 per cent. These symptoms occurred most frequently when intermittent bronchial obstruction was present.

5. Wheezing was noted as an early symptom in 6 per cent of the patients, resulting, of course, from partial obstruction of a bronchus by the growth.

Many other symptoms were reported by the patients in this series. The majority of these symptoms should not be included in a discussion of early manifestations of the disease, for they were attributable to late stages and to metastatic extensions of the tumor. Weight loss was reported by 35 per cent of the patients. Dyspnea was the first symptom in but one case and was present in only 24 per cent of the entire group. Weakness was a late symptom and was present in 16 per cent of the patients.

## CLINICAL STUDY AND DIAGNOSIS

The clinical signs that may be elicited in the chest of a patient suffering with primary malignancy are extremely variable. A small stem bronchus tumor not obstructing the bronchus, or a peripheral tumor not extending completely to the thoracic wall, may not produce signs. When the growth obstructs a major bronchus, causing atelectasis of a lobe, the usual findings are dullness on percussion over the affected area, absence or diminution of breath sounds, and an increased trans-

mission of voice sounds. The findings, when the growth occupies a position in the parenchyma of the lobe, depend entirely upon the position and size of the tumor. Suppuration, secondary to the growth, may alter the physical findings considerably. Pleural effusion is a rare early occurrence and was found in but one of our operable cases. An effusion was demonstrated in 11 per cent of the entire series of primary pulmonary malignancy. Findings of mediastinal glandular enlargement, phrenic paralysis, engorgement of the veins of the neck and thorax, and bloody pleural fluid are all late signs of the disease. Evidences of an associated pulmonary infection were present in 55 per cent of the patients studied, as indicated by fever and polymorphonuclear leucocytosis.

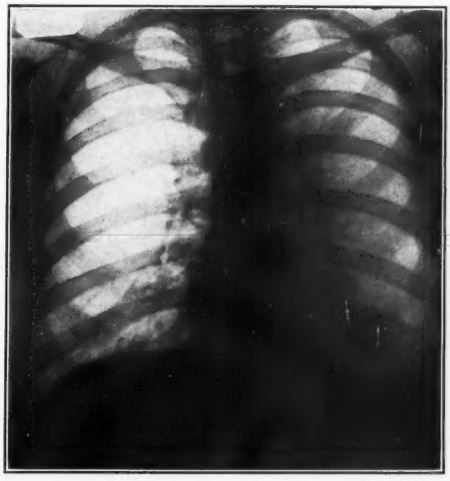

Fig. 1.—Preoperative roentgenogram (Case 21, Table III) showing diffuse cloudiness of left lung field (atelectasis) due to benign tumor in left main stem bronchus. Note that the tumor itself fails to cast a shadow. The roentgenogram in this case presented only presumptive evidence of neoplastic disease. The diagnosis was established by bronchoscopy and was confirmed by thoracic exploration and excision of the left lung.

The chest roentgenogram is essential in the study of suspected cases of primary carcinoma of the lung. Presumptive evidence is often obtained. Tumors originating in the main bronchi soon produce atelectasis of a lobule, lobe, or the entire lung. The atelectatic shadow appears in the roentgenogram when the tumor itself fails to do so (Figs. 1 and 2). Lateral and oblique exposures aid in the interpretation of the lobar and lobular shadow.

Tumors arising outside the main bronchi appear as areas of increased density, usually uniform, rounded, and well delineated from the surrounding lung tissue. Bronchograms made after the instillation of lipiodol may give additional information.

Bronchoscopy is equally as important as the x-ray examination. It is essential in the stem bronchus type of lesion which, in our experience, represents 78 per cent of all cases of primary lung cancer (50 in a series of 64). The tumor is visualized and its location determined (Fig. 3). This procedure frequently yields tissue for positive histologic diagnosis. In forty-three of the fifty patients in our series who had a stem bronchus carcinoma, a positive biopsy was obtained. This gives an incidence of positive clinical discovery in bronchial carcinoma of 86 per cent. Examination bronchoscopically also makes it

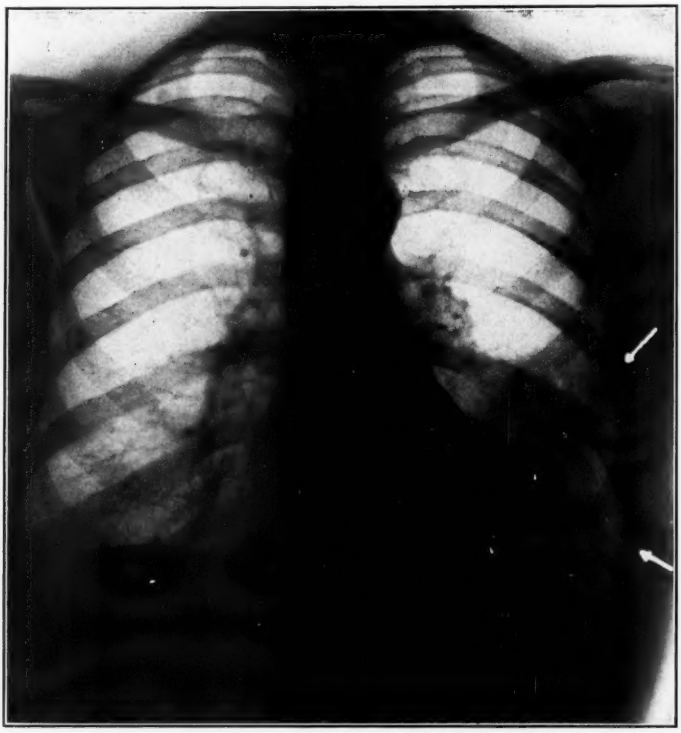

Fig. 2.—Preoperative roentgenogram (Case 2, Table III) showing cloudiness of left lower lung field (lobular atelectasis) due to carcinoma of the lingual branch of the bronchus of the left upper lobe. Note the absence of a discrete shadow indicative of tumor. The atelectatic shadow yielded presumptive evidence of bronchial obstruction. Bronchoscopic examination was made and the diagnosis established. Lateral or oblique roentgenograms aid in the localization of lobular atelectatic shadows.

possible to determine the exact location of the growth, mobility of the trachea, and the angle of the bifurcation. If suppuration is present behind an occluding tumor, bronchoscopic dilatation may temporarily improve the patient's condition preparatory to exploratory thoracotomy. Tumors not within the range of bronchoscopic visibility and

biopsy, i.e., principally the peripheral lesions, may require additional investigation. The examination of the sputum may show the presence of fragments of the growth. Dudgeon[10] has described a "wet film" method of studying sputum with which he has been able to discover malignant cells in the sputum of 60 per cent of patients who subsequently have been found to harbor a pulmonary neoplasm. Peripheral tumors shown by roentgenogram to be adjacent to the pleura may yield diagnostic material upon thoracentesis and aspiration. In one patient of our series in whom a peripheral tumor was suspected, a diagnosis was established in this way. This method of obtaining material for microscopic study is not without danger, especially in cases where there is

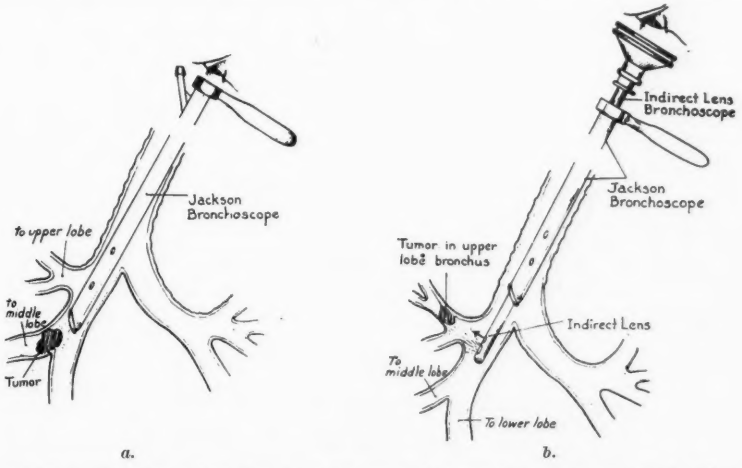


Fig. 3.—Drawing which illustrates the essential value of bronchoscopy in the diagnosis of stem bronchus tumors. Three-fourths of all primary lung tumors originate within the main stem bronchi and are within the range of bronchoscopic vision: *a*, standard distally illuminated Jackson bronchoscope; *b*, retrograde telescopic bronchoscope which is used for visualization of bronchi of the upper lobes. This instrument is inserted within the standard bronchoscope. The lens system permits a range of vision between 90° and an acute angle of 45°.

an associated pulmonary suppuration. Attempts at aspiration are definitely contraindicated in stem bronchus tumors because of the frequency of associated suppuration distal to the lesion. This makes the occurrence of pleural contamination a possibility, a complication which would seriously interfere with subsequent surgery. The high incidence of successful bronchoscopic biopsy in stem lesions also renders aspiration biopsy practically devoid of indication. After a presumptive diagnosis has been made of a peripheral tumor by roentgenogram, thoracic exploration is indicated regardless of a negative or positive aspiration biopsy (provided there is no evidence of extension beyond the lung). We, therefore, limit aspiration biopsy to those peripheral tumors which are obviously inoperable.

Patients with histologically proved cancer of the lung, or those in whom a presumptive diagnosis of cancer has been made, warrant thoracic exploration, provided metastatic disease cannot be demonstrated and provided general contraindications do not exist. Constitutional effects of an associated infection per se do not necessarily contraindicate lung resection. Removal of the lung containing the tumor also relieves the patient of the associated infected tissue. Recovery from both conditions may then proceed simultaneously.

## TECHNICAL CONSIDERATIONS

The technique employed in recent cases of pneumonectomy has not varied greatly from the author's description of the operation published previously.[40]

*Pneumothorax* is still considered a valuable preparatory measure if its induction is possible and if a collapse of 40 per cent or more of the lung is obtained. The involved lung is gradually collapsed by such a procedure. The lung becomes more completely emptied of secretions prior to operation. The pulmonary circulation in the involved lung is reduced. The ability of the remaining lung to carry on can be determined in advance of resection. Pneumothorax is maintained and operation delayed until dyspnea disappears or decreases and the vital capacity reading reaches its maximum. This may require from two to six weeks. Obstruction of the bronchus with associated suppuration distal to the block may contraindicate maintenance of the pneumothorax.

*Anesthesia.*—Cyclopropane, administered through an intratracheal tube, has been used to the practical exclusion of all other forms of anesthesia in our cases. Cyclopropane gas permits the simultaneous administration of high concentrations of oxygen and a quiet even type of anesthesia. The particular advantage of this form of anesthesia in thoracic surgery has been discussed by Eversole and Overholt.[15] Previous intubation of the trachea permits a positive control of gas pressures and gives access to the trachea and main bronchi for aspiration of accumulating secretions during anesthesia. The use of an intratracheal tube has worked out in a practical way to better advantage than an intrabronchial tube.

*Continuous Venoclysis.*—Operative shock is combated by inserting a cannula in the saphenous vein above the ankle and administering glucose solution or citrated blood throughout the entire operative period.

*Exposure.*—Both anterior and posterolateral incisions have been used, depending upon the ease of lung mobilization and the likelihood of subsequent infection. Should difficulties with either be anticipated, a posterolateral incision is preferred. The posterolateral approach permits a wider and more varied exposure of the hilum and mediastinum.

The anterior approach has the advantage of providing an immediate exploration of the anterior mediastinum without extensive mobilization of the upper lobe.

*Exploration.*—In cases of stem bronchus carcinoma, previously verified by bronchoscopic biopsy, the surgical exploration is concerned principally with the determination of mediastinal extension of the tumor. The character of the tumor itself and the condition of the lung or visceral pleura are of much less importance. In all of the inoperable explored cases, the mediastinal glands were involved. An extension of the tumor to the periphery of the lung or pleura was found in only two instances in the stem bronchus group. An incision of the mediastinal pleura, circumferential to the hilum, exposes the more superficial lymphatic glands. Dissection and retraction of the pulmonary artery permits exposure of the lymphatic glands which lie adjacent to the main bronchus (Figs. 4 and 5). The frequency of an associated infection in pulmonary malignancy is cause for the almost universal finding of enlarged mediastinal glands. Some of the glands are usually firm to palpation and are heavily pigmented. Routinely, one or more glands are removed for histologic examination after frozen section. In most cases, this can be done without adding to the risk of exploration. In one instance (Case 3, Table III), a difficult mediastinal dissection was followed by serious bleeding which required pulmonary artery ligation. The tumor had invaded the mediastinum and pulmonary vein. The completion of the pulmonary resection was considered to be of less risk than a conclusion of the exploration without resection. Except for this case, we have not purposely continued with pneumonectomy in the face of mediastinal involvement. Undoubtedly, in the future, palliative pneumonectomy will be justified in a higher proportion of cases. In the event of a suppurating lung distal to the occluding bronchial tumor, temporary relief and a prolonged life might be afforded by pneumonectomy.

Frequently, in peripheral types of neoplasms, histologic confirmation of the diagnosis is not obtainable prior to exploration. A great deal, therefore, depends upon inspection and palpation of the mass within the lung. With the thorax open, we have preferred to depend upon the gross appearance of the lesion within the lung rather than to risk infection of the pleural space by transecting lung substance to secure a biopsy. The same applies to aspiration biopsy with the pleural cavity open. In the majority of cases, however, the peripheral tumor extends to the surface of the lung and causes a characteristic puckering. A small wedge of this tissue may be removed safely for biopsy. In the event of invasion of the chest wall, the matter of obtaining a biopsy presents little difficulty.

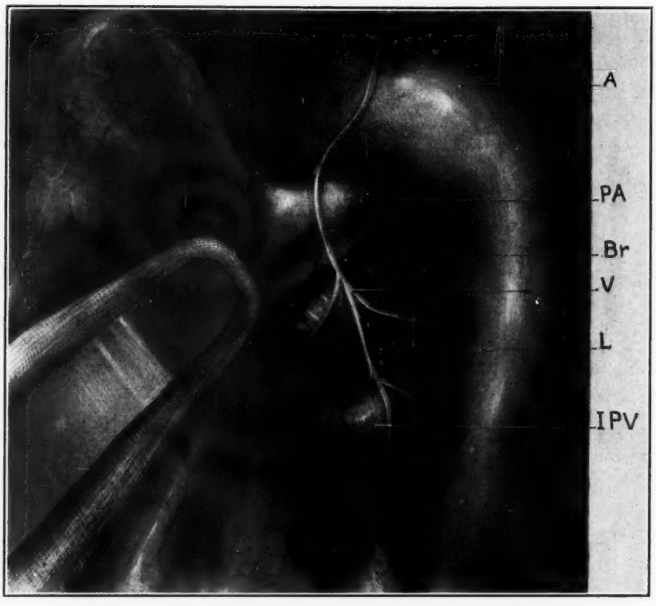


Fig. 4.—Exposure of the posterior aspect of the left pulmonary hilum preparatory to removal of mediastinal lymphatic glands for frozen section, immediate histologic examination, and determination of mediastinal glandular metastasis. The mediastinal pleura has been opened. This structure is not shown in the drawing. Note relationship of lymphatic glands to major bronchus, *A*, aorta; *P.A.*, pulmonary artery; *Br.*, left main bronchus; *V*, vagus nerve; *L*, lymph gland; *I.P.V.*, inferior pulmonary vein. The superior pulmonary vein is obscured by the other structures of the hilum and is not shown.

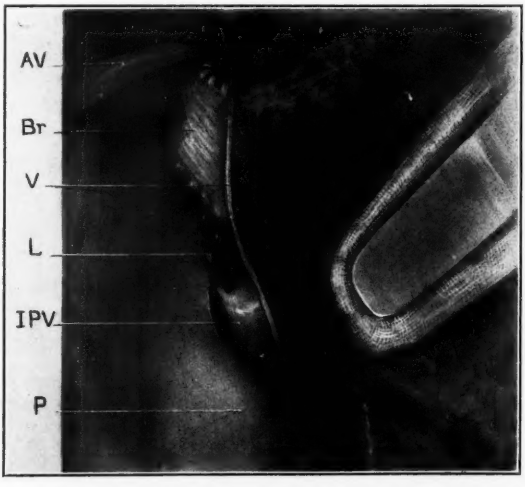


Fig. 5.—Exposure of the posterior aspect of the right pulmonary hilum preparatory to removal of mediastinal lymphatic glands for frozen section diagnosis. The mediastinal pleura has been opened and is not shown in the drawing. *A.V.*, azygos vein; *Br.*, right main bronchus; *V*, vagus nerve; *L.*, lymph gland; *I.P.V.*, inferior pulmonary vein; *P*, pericardium.

### TREATMENT OF THE STRUCTURES OF THE HILUM

The variation in the anatomy of the two hilar regions requires some variation in the resection on the two sides. On the left side, the pulmonary artery is routinely dissected, ligated, and divided as the first step (Fig. 4). The aorta somewhat limits the exposure of the structures on this side so that the bronchus can be prepared for division with greater ease if the pulmonary artery has been divided previously. Injury to the principal fibers of the vagus nerve is avoided by dividing branches joining the pulmonary plexus and displacing the nerve itself medially. The recurrent nerve is seldom exposed and has never been divided in any of our cases. When complete mobilization of the lung has been accomplished prior to the treatment of the hilum, the two pulmonary veins are ligated and divided as the second and third steps. The lung is then attached solely by the bronchus. This permits traction of this structure and facilitates its section near the bifurcation of the trachea. In the event of incomplete mobilization of the lung before treatment of the hilum, it has proved expedient to divide the bronchus immediately after the ligation of the pulmonary artery, temporarily closing the proximal end, and then to proceed by ligating and dividing the superior followed by the inferior pulmonary vein. Finally, the lung itself is completely liberated. The extrapericardial portion of the inferior pulmonary vein is between 5 and 10 mm. in length. The extreme shortness of this vessel and the tendency for the pericardium to be drawn out with it upon application of traction make opening of the pericardium a definite possibility during dissection. This technical complication would be serious if the field had been previously contaminated. After the lung is lifted out of the thorax, attention is returned to completion of the bronchial closure. Early section of the bronchus has the advantage of preventing an escape of secretions from the lung itself into the trachea and contralateral bronchi while the lung is being mobilized and the hilum dissected.

On the right side, the pulmonary artery is situated more completely on the anterior surface of the right main bronchus and does not cover the bronchus superiorly as it does on the left side (Fig. 5). When the approach is an anterior one, the artery is ligated as the first step. In approaching the hilum through a posterolateral incision, the right main bronchus can be dissected out as the first step. The azygos vein may interfere with a high division of the right main bronchus. Its ligation and division as a preliminary step is at times necessary. Care should be exercised to avoid injury of the bronchial artery proximal to the point of division of the bronchus. The meticulous closure of the proximal end is then delayed until the pulmonary artery and the two pulmonary veins have been disposed of and the remainder of the mobilization of the lung completed.

CLOSURE OF THE BRONCHUS

Various methods designed to insure permanent closure of the bronchus have been employed by different surgeons. In experimental work, bronchial leakage, tension pneumothorax, and empyema were the principal causes of death in animals. In human beings the occurrence of a temporary bronchial fistula following lobectomy has been relatively common. In the collected cases of pneumonectomy (Tables I and II), the development of a bronchial fistula was reported twenty-one times in forty-six cases, an incidence of 45 per cent. In our own experience, the bronchus has opened in five of the twenty-two patients

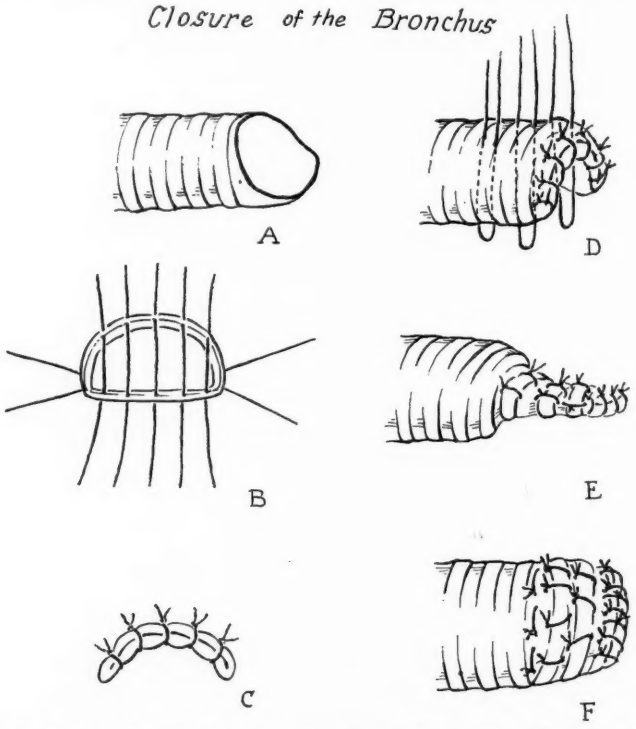


Fig. 6.—Illustration of method of suturing bronchus: *A*, end of bronchus divided obliquely; *B*, end and guy sutures; *C*, closure of end of bronchus; *D*, placement of proximal mattress sutures; *E* and *F*, completed closure of bronchus with anterior and posterior walls in apposition.

(22.7 per cent) and was probably responsible for the death in two of the five fatal cases. The method used in fifteen operations has been similar to that described by Rienhoff.[44] Two traction sutures are inserted before dividing the bronchus proximal to the line of incision. The bronchus is cut on an angle, leaving the posterior wall longer than the cartilaginous anterior and lateral portions. The bronchial artery is carefully preserved throughout the full length of the bron-

chial stump. Fine interrupted silk sutures, which pass through all layers, are used to approximate the end of the bronchus. From eight to ten mattress sutures are then inserted through the bronchial wall, anterior to posterior, with the loops placed parallel to the direction of the bronchus. The distance that these sutures are placed proximally in the bronchus depends upon the length of the stump. An effort is made to bring into apposition from 1.5 to 2.5 cm. of the bronchial wall. Care is exercised in the placement of the mattress sutures to avoid the bronchial artery (Fig. 6). Methods of sectioning cartilaginous rings and infolding mucosa were abandoned in two operations when attempted.

### CLOSURE

Drainage has not been employed except in those instances where there has been previous infection in the pleural cavity or obvious contamination during the course of operation. In three cases (15, 17, and 20), a drain was considered necessary at the time of closure. In these three cases, and in two patients not drained at the time of operation, bronchial fistulas formed. Airtight closure of the chest with a re-establishment of the rigidity of the thoracic wall aids respiratory function after operation since pendulum motion of the mediastinum is prevented. At the conclusion of the operation, the intrathoracic pressure is determined and sufficient air aspirated to bring the pressure down to the normal intrapleural pressure.

### POSTOPERATIVE CARE

Oxygen therapy is given routinely for twenty-four hours or longer, if necessary. Intrathoracic pressure readings are taken at regular intervals of eight to twelve hours, and air or fluid is aspirated to maintain a slightly negative intrathoracic pressure. The position of the mediastinum is determined by bedside roentgenograms. An emergency set of instruments for introducing an intercostal drain is kept at the bedside to be used if a bronchial fistula of sufficient size to permit an escape of fluid into the contralateral lung forms. This was necessary in two patients (Cases 9 and 19).

### SUBSEQUENT THORACOPLASTY

In the early history of the operation, the matter of obliterating the thoracic space created by total lung removal was the subject of much discussion. In Graham's first case,[21] thoracoplasty was performed at the time of pneumonectomy. O'Brien[37] prefers to carry out thoracoplasty some days or weeks in advance of pneumonectomy. Rienhoff[42] has pointed out that the thoracic space fills up with serum which coagulates, forming a space-occupying substance, and that thoracoplasty may never be necessary. This has been our experience. Thoracoplasty has been done for only two patients in our series (Cases 1 and 19). In these cases, the intrathoracic space became infected and

TABLE III

AUTHOR'S CASES OF PNEUMONECTOMY FOR MALIGNANT LESIONS

| CASE NUMBER | PATIENT | OPERATIVE RECOVERY, SURVIVED 2 MONTHS OR MORE | YEAR OF OPERATION | DIAGNOSIS | AGE | SEX | SIDE OF OPERATION | APPROACH | | TREATMENT OF HILUM | | | DRAINAGE (P, PACK; T, TUBE) | BRONCHIAL FISTULA | CAUSE OF DEATH | SURVIVAL AFTER OPERATION | METASTASES FOUND LATER | SUBSEQUENT THORACOPLASTY | PRESENT STATE OF HEALTH | DURATION OF SURVIVAL AT LAST REPORT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ANTERIOR | POSTERIOR | MASS LIGATION | INDIVIDUAL LIGATION | SUTURE MATERIAL (C, CATGUT; S, SILK) | | | | | | | | |
| 1 | Mrs. A. T. | + | 1933 | Unclassified carcinoma | 33 | F | R | + | - | + | - | S & C | - | - | | | - | + | Excellent | 4 yr., 11 mo. |
| 2 | Mrs. E. H. | + | 1934 | Carcinoma simplex | 45 | F | L | - | + | + | - | C | - | - | | | - | - | Excellent | 4 yr., 4 mo. |
| 3 | Mr. W. S. | - | 1934 | Epidermoid carcinoma | 43 | M | L | - | + | + | - | C | - | - | Hemorrhage | 2 days | + | - | | |
| 4 | Mr. H. C. | - | 1934 | Small cell carcinoma | 37 | M | L | - | + | + | - | C | - | - | Hemorrhage | Day of operation | - | - | | |
| 5 | Mr. J. R. | - | 1934 | Adenocarcinoma | 50 | M | R | - | + | - | - | S & C | - | - | Empyema and pneumonia | 6 days | - | - | | |
| 6 | Mrs. M. C. | + | 1935 | Carcinoma simplex | 59 | F | L | + | - | - | + | S & C | - | - | Unknown | 1 yr. | Autopsy negative | - | | |
| 7 | Mr. M. G. | + | 1936 | Epidermoid carcinoma, Grade II | 45 | M | L | + | - | - | + | S & C | - | - | | | - | - | Excellent | 2 yr., 5 mo. |
| 8 | Mr. A. T. | + | 1936 | Oat-cell carcinoma | 56 | M | L | - | + | - | + | S & C | - | - | Metastases to liver | 4 mo. | + | - | | |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | Mr. C. H. | – | 1936 | Epidermoid carcinoma | 53 | M | L | – | + | – | + | S & C | – | + | Empyema and pneumonia | 26 days | – | – | | |
| 10 | Mrs. T. K. | + | 1937 | Unclassified carcinoma | 45 | F | L | – | + | – | + | S & C | – | – | | | – | – | Excellent | 1 yr., 9 mo. |
| 11 | Mrs. S. B. | + | 1937 | Adenocarcinoma | 45 | F | R | – | + | – | + | S & C | – | – | | | – | – | Excellent | 1 yr., 3 mo. |
| 12 | Mr. I. B. | + | 1937 | Epidermoid carcinoma, grade II | 51 | M | R | – | + | – | + | S & C | – | – | | | – | – | Improved | 11 mo. |
| 13 | Mrs. S. S. | + | 1938 | Adenocarcinoma | 53 | F | L | – | + | – | + | S & C | – | – | | | – | – | Excellent | 6 mo. |
| 14 | Mr. S. H. | + | 1938 | Unclassified carcinoma | 34 | M | L | – | + | – | + | S & C | – | – | | | – | – | Excellent | 5 mo. |
| 15 | Mr. D. J. | – | 1938 | Carcinoma simplex | 47 | M | L | – | + | – | + | S & C | T | + | Empyema preceded operation; hemorrhage | 30 days | At stump | – | | |
| AUTHOR'S CASES OF PNEUMONECTOMY FOR BENIGN LESIONS | | | | | | | | | | | | | | | | | | | | |
| 16 | Mrs. E. A. | + | 1934 | Abscess | 44 | F | L | – | + | + | – | S & C | – | – | Pneumonia | 7 mo. | – | – | | |
| 17 | Mrs. C. C. | + | 1935 | Multiple abscesses | 28 | F | L | – | + | + | – | S & C | T | + | Renal infaret | 8 mo. | – | – | | |
| 18 | Mrs. F. C. | + | 1937 | Abscess | 32 | F | R | – | + | – | + | S & C | – | – | | | – | – | Excellent | 1 yr., 4 mo. |
| 19 | Miss L. Q. | + | 1937 | Bronchiectasis | 25 | F | R | – | + | – | + | S & C | – | + | | | – | + | Excellent | 1 yr., 2 mo. |
| 20 | Miss E. G. | + | 1937 | Multiple abscesses | 10 | F | R | – | + | + | – | S & C | T | + | | | – | – | Excellent | 10 mo. |
| 21 | Mrs. M. C. | + | 1938 | Bronchial adenoma | 37 | F | L | – | + | – | + | S & C | – | – | | | – | – | Excellent | 6 mo. |
| 22 | Mr. J. M. | + | 1938 | Bronchial stenosis | 38 | M | L | – | + | – | + | S & C | – | – | | | – | + prelim. | Still in hospital | |

the space failed to become obliterated. In one patient who has had a right-sided pneumonectomy, thoracoplasty is being considered (Case 12). This patient has constant chest pain, apparently as a result of a contracting fibrothorax.

### STATUS OF SURVIVING PATIENTS

All patients, except two, who survived pneumonectomy for carcinoma of the lung are still living, the longest survival time being 4 years and 11 months. Five of the patients operated upon for benign lesions are still living, bringing the total survivors of pneumonectomy in our series up to thirteen. These patients are all enjoying excellent health without marked limitation of activity, except the one patient mentioned above (Case 12) and the most recently treated patient who is still in the hospital (Case 22). There is no thoracic deformity except in the two patients requiring thoracoplasty; and when they are clothed, there is no obvious deformity in these two patients. None complains of dyspnea. None shows evidences of circulatory embarrassment. Postoperative electrocardiograms have uniformly shown no appreciable change.

Among the carcinoma group, it seems significant that only one patient (Case 8) has succumbed to metastatic disease. The second late death resulted from other causes, and autopsy failed to reveal residual malignant tissue.

### CASE REPORTS

For convenience, the detailed case reports have been grouped according to the indication for operation. The first six patients treated for carcinoma of the lung were previous reported[39] so are not included among the detailed reports, but appear in the appended Table III. Likewise, the first two patients operated upon for pulmonary suppuration (Cases 16 and 17) were previously reported.[39]

### CONCLUSIONS

1. One hundred and ten cases of pneumonectomy have been recorded in the literature, sixty-two being done for malignant lesions and forty-eight for benign lesions.

2. The mortality in the collected series (excluding all cases up to the first successful operation in 1931) has been found to be 65 per cent in the malignant group and 24 per cent in the benign group.

3. The author's series of pneumonectomy cases includes fifteen treated for malignancy with an operative mortality of 33.3 per cent and seven treated for benign lesions without an operative death.

4. Clinical studies in sixty-four patients led to a diagnosis of primary malignancy of the lung with histologic verification before death in fifty-nine.

5. Thoracic exploration was indicated in over one-half of the patients (33) harboring pulmonary cancer, as evidence of extension of the tumor beyond the lung could not be demonstrated upon clinical examination.

6. Over one-half of the explored cases proved to be operable. Pneumonectomy was performed upon fifteen patients, and lobectomy upon three. This places the operability of primary cancer of the lung in this series at approximately 25 per cent.

The author wishes to acknowledge his appreciation for the cooperation given in this work by his present associates and former assistants who aided materially in the surgical management of these patients: Dr. Reeve H. Betts, Boston, Mass.; Dr. John S. Harter, Sanatorium, Miss.; and Mr. O. S. Tubbs, London, England. Responsibility for anesthesia was placed in the hands of Dr. Sidney C. Wiggin and associates and Dr. Lincoln F. Sise and associates. Dr. Shields Warren made the pathologic interpretation on all biopsy and surgical specimens.

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## CASE REPORTS

CASE 7.—M. G., male, aged 45 years, salesman.

*Symptoms.*—Five months previously the patient contracted a sore throat and a head cold which was treated by several weeks of bed rest. Following this, the patient tired easily after slight exertion and continued to have a persistent, nonproductive cough. The patient's weight decreased from 194 to 155 pounds in 4 months. Laboratory studies made at that time were essentially negative except for a white blood cell count of 24,000. A chest roentgenogram revealed a shadow in the left lung field interpreted as an interlobar collection of fluid which disappeared following aspiration. There were no other significant symptoms except an occasional stomach "upset" with vomiting during the 5-month period. There was no complaint of chest pain or dyspnea and no hemoptysis. The fluid aspirated from the left chest was sterile upon culture, and guinea pig inoculation failed to show the presence of tubercle bacilli.

*Examination.*—Upon physical examination, no remarkable abnormalities were found except for altered signs over the left upper chest. Here the percussion note was slightly diminished and the breath sounds were depressed. Further examination revealed: no râles; blood pressure, 140/85; no cyanosis; finger tips not clubbed; superficial lymphatic glands not palpable.

*Laboratory Examination.*—Routine laboratory examinations revealed no notable abnormalities.

*X-ray Examination.*—The roentgenogram of the chest showed an area of increased density in the region of the left upper lobe with slight deviation of the trachea and heart to the left. The intercostal spaces were slightly narrowed on the left side. The interpretation was atelectasis of the lingual portion of the left upper lobe. Skeletal roentgenograms were negative.

*Bronchoscopy.*—The orifice of the left upper lobe bronchus was narrowed and the mucosa was markedly reddened and inflamed. Tissue from this area was removed for biopsy and the report was "epidermoid carcinoma, Grade II."

*Preparation.*—Left pneumothorax was induced April 14, 1936, and an 80 per cent collapse was established within a period of 5 days. This collapse was maintained for 1 month. During the first half of this period, the patient complained of moderate dyspnea. The vital capacity on May 12, 1936, was 1,750 c.c.

*Operation.*—Left pneumonectomy was performed May 13, 1936, under intratracheal cyclopropane anesthesia. An anterior approach was used. The third rib was resected, and the second and fourth cartilages were divided. The anterior mediastinum was exposed. Lymphatic glands were not enlarged. A tumor mass could be palpated at the juncture of the main stem and upper lobe bronchus. The structures of the hilum were then treated separately in the following order: the pulmonary artery, the superior pulmonary vein, the bronchus, and finally the inferior pulmonary vein. The lung itself was then mobilized. Extensive and firm pericardial and diaphragmatic adhesions made this part of the dissection difficult and time-consuming. Edges of mediastinal pleura were sutured over the ligated vessels and bronchial stump. The thoracic wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—"The left lung weighs 395 gm. There is a mass of firm tumor tissue involving the bronchial wall at the junction of the upper and lower lobe bronchi, the walls of which are thickened. There is metastasis to one adjoining lymphatic gland."

*Convalescence.*—The patient was placed in an oxygen tent for 24 hours. Breathing was not labored. For 2 days there was very little reaction, but between the third and sixth days the temperature ranged between 99° and 101° F. After that time, the temperature was essentially normal except during the fifth week of the convalescence when a low-grade fever developed. On the twelfth day the skin sutures were removed, and the wound had apparently healed by first intention. The next day clear, thin serum began to escape from the lower angle of the wound in small amounts. After a period of several weeks this gradually diminished, and firm healing followed. Thoracentesis on four occasions as late as the ninth postoperative day yielded blood-tinged fluid which was sterile upon culture. The patient was discharged from the hospital on the fifty-second postoperative day.

*Follow-Up.*—The patient was last examined Aug. 29, 1938, 2 years and 3 months after operation. The patient reported that he was in good health but admitted that he had moderate dyspnea and tachycardia on exertion. He had had no other respiratory or other systemic symptoms. Examination revealed the patient in a good general state of nutrition. His weight was 186 pounds. Recurrence was not in evidence. Inspection of the chest showed slight depression of the infraclavicular area on the left, but otherwise the chest was symmetrical. The chest roentgenogram showed an area of opacity throughout the left side with a definite diminution in

the area of the left hemithorax. The heart and mediastinal structures were displaced to the left. He had been doing office work and was planning to resume full-time work.

CASE 8.—A. G. T., male, aged 56 years, American, lawyer.

*Symptoms.*—For a period of 2 years the patient had had a nonproductive cough and for 8 months had noticed a wheeze in his left chest with occasional attacks of fever. Later the cough became more productive, and, on occasions, the sputum was streaked with blood. A significant point in the past medical history was that 25 years previously he had had an active tuberculous process in the left lung with positive sputum. After a few months of rest treatment, his symptoms disappeared and he gradually returned to work. From that time on, he had no symptoms referable to the chest until the present illness.

*Examination.*—All abnormal findings were limited to the left chest. Motion on this side was restricted. The percussion note was dull both posteriorly and anteriorly. Breath sounds were diminished at the base and had an amphoric quality in the anterior upper chest. Signs of metastatic disease could not be found.

*Laboratory Examination.*—The routine studies were essentially negative except for a slight anemia.

*X-ray Examination.*—X-ray of the chest revealed a diffuse increase in density of the left hemithorax with narrowing of the intercostal spaces and shift of the mediastinal structures to the left.

*Bronchoscopy* (performed by Dr. J. W. Taylor, Tampa, Fla.).—"Left main bronchus from carina to bifurcation of bronchi normal. Bronchial rings distinct. At the lower lobe bronchus, a mass was seen that involved both upper and lower lobe bronchi. The mass bleeds on contact. Specimen for biopsy." Microscopic diagnosis was "carcinoma, anaplastic type."

*Preparation.*—Pneumothorax was attempted but was unsuccessful.

*Operation.*—Left pneumonectomy was performed Sept. 28, 1936, under intratracheal cyclopropane anesthesia. A posterolateral incision was used. Upon opening the thorax, an extremely thick pleura was found, and a cleavage plane between the two pleural surfaces could not be obtained. The lung was therefore mobilized by separating the parietal pleura from the endothoracic fascia. The mediastinum was exposed and the left main bronchus dissected. Tumor tissue which had invaded the bronchial wall formed a whitish plaque on the wall of the bronchus. Frozen section of tissue from this area revealed malignant cells. Adjacent glands were apparently not involved. Resection of the lung was decided upon, regardless of the findings of the exterior invasion of the bronchial wall, as exploration alone would not have been tolerated as safely as resection. The structures of the hilum were treated separately. A portion of pericardium was removed with the lung in completing the mobilization of the lingual portion of the upper lobe. This defect was repaired. No drainage was used.

*Pathologic Report: Gross Specimen.*—"The specimen consists of entire left lung. Mass 5 × 3 × 3 cm. in the upper lobe. Within the main bronchus and grouped about its bifurcation are several nodular firm excrescences. Lower lobe bronchus is patent, and the upper is occluded. On section, a dense white tumor appears to extend from the infiltrated bronchial wall. Peripherally, the tissue of most of the lower lobe is mottled white, black, and pinkish-yellow. White portions are granular and opaque. There are small foci of caseation. Microscopic diagnosis was (a) oat-cell carcinoma and (b) tuberculosis."

*Convalescence.*—The patient's course after operation was uneventful except for the interval between the ninth and eighteenth postoperative days when an intermittent fever as high as 101° F. occurred. Fluid aspirated from the left chest 4

days after operation showed *Staphylococcus aureus* upon culture. A bronchial fistula did not form. The wound healed normally, and the patient was discharged from the hospital on the thirty-second postoperative day.

*Follow-Up.*—The patient was comparatively well for a period of 4 months and resumed his professional work. Evidences of metastatic involvement of the liver then appeared, and death followed soon afterward. Post-mortem examination was not done.

CASE 9.—C. H., male, aged 53 years, American, weaver.

*Symptoms.*—The principal symptoms were chronic cough of 3 years' duration, pain in the left chest, and dyspnea for a period of 1 year. Recently, the cough became productive of a mucoid material but never contained blood. There had been a loss of 20 pounds in weight.

*Examination* revealed a thin, middle-aged man, appearing older than his age. The chest was barrel type with diminished excursion on the left side. Percussion note was dull over left chest anteriorly and diminished in resonance posteriorly. The breath sounds were diminished throughout the left chest. Râles were not audible.

*Laboratory Examination.*—The white blood cell count was 13,600. The phenolsulphonephthalein renal function test showed 12 per cent dye elimination the first hour, and 25 per cent for the second hour. The vital capacity was 3,200 c.c.

*X-ray Examination.*—"The left lung field shows an area of density from the ninth rib posteriorly to the apex. The heart and great vessels are displaced to the left. The x-rays of the skeleton are negative."

*Bronchoscopy.*—The left upper lobe bronchus was obstructed by a mass which projected into the left main stem bronchus. The carina was not widened. The trachea was normally mobile. Report on biopsy was "epidermoid carcinoma, Grade II."

*Preparation.*—Left pneumothorax was induced Oct. 19, 1936. Approximately a 40 per cent collapse was obtained.

*Operation.*—Left pneumonectomy was performed Nov. 3, 1936. Right endobronchial cyclopropane anesthesia was administered. A posterolateral incision was used. The tumor mass could be palpated at the bifurcation of the bronchus, and glands anterior and above the pulmonary artery were negative. The mediastinum was mobile. The lung was resected. After dividing the pulmonary artery and bronchus, a single gland on the medial surface of the bronchus was found which contained tumor cells. This gland was removed. The wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—The left lung weighed 460 gm. A large, firm mass was present in each lobe. The wall of the bronchus was thickened, granular, and opaque on its inner surface. Upon sectioning the lung, an abscess cavity was opened in each lobe. The tumor tissue itself formed a comparatively small portion of each original mass. Microscopic diagnosis was epidermoid carcinoma, Grade III, atelectasis, fibrosis, and inflammation.

*Postoperative Course.*—The patient's course was entirely satisfactory until the fourteenth postoperative day when he began to expectorate bloody fluid of the same character as that aspirated from the left pleural cavity. The fluid from the pleural cavity at this time showed upon culture a slowly growing hemolytic *Staphylococcus aureus.* Obviously, the bronchial stump had opened. An intercostal catheter was inserted, and the right tracheobronchial tree was aspirated bronchoscopically. Improvement followed, the temperature became normal, and the pulse ranged between 100 and 110. The drainage tube functioned properly, and the infection of the pleural space seemed to be controlled. On the twenty-sixth postoperative day, the patient had a sudden massive hemoptysis and expired within a few minutes. Permission for post-mortem examination was not granted.

CASE 10.—T. K., female, aged 45 years, housewife.

*Symptoms.*—The patient had been in perfect health until 4 years previously when a chronic, nonproductive cough developed without apparent cause. Subsequent upper respiratory tract infections had no effect upon the frequency or severity of the coughing spells. The usual cough remedies gave only temporary relief. Two years ago the cough became productive of small amounts of mucoid material occasionally streaked with blood. This development led to repeated examinations of the sputum for tubercle bacilli, but none was found. In November, 1936, the patient entered the Essex County Sanatorium for observation.

*Examination* revealed a healthy-appearing, middle-aged woman in no apparent distress. The temperature was normal; rate of the pulse, 72; blood pressure, 120/80; weight, 125 pounds. The findings were essentially negative except those referring to the thorax. Expansion was slightly limited on the left. The percussion note was diminished in the left infraclavicular region and at the extreme apex of the left chest posteriorly. In these same areas the breath sounds were suppressed. The heart was in its normal position, and the trachea was in the midline. Cervical lymph glands were not enlarged, and glands in other areas were not palpable. Slight clubbing of the finger tips was noted.

*Laboratory Examination.*—The blood count showed 22,900 white cells with 83 per cent polymorphonuclear leucocytes. The remainder of the blood count was negative, as was also the urinalysis. The blood sedimentation rate was moderately accelerated. The Hinton test was negative. The electrocardiogram was normal. The nonprotein nitrogen was 27 mg. per cent.

*X-ray Examination.*—The chest roentgenogram showed a shadow of homogeneous density occupying the upper third of the left lung field. The hilar shadows did not appear enlarged. There was little displacement of the thoracic viscera. Skeletal roentgenograms showed no evidence of bony metastasis.

*Bronchoscopy* revealed an intrabronchial mass of tissue protruding into the left main stem bronchus from the orifice of the left upper lobe. The base of the tumor mass could not be visualized, and the mucosa adjacent to the projecting tumor was not involved. The carina was not widened, and the lower end of the trachea was normally mobile. A biopsy specimen was obtained, the report being "bronchiogenic carcinoma, unclassified."

*Preparation.*—Left intrapleural pneumothorax was induced and an 80 per cent collapse maintained for a period of 6 weeks. The patient was then transferred to the New England Deaconess Hospital. The preoperative vital capacity with the pneumothorax in force was 1,000 c.c.

*Operation.*—Left pneumonectomy was performed Jan. 5, 1937, under intratracheal cyclopropane anesthesia. A posterolateral approach was used. Exploration of the mediastinum showed no evidence of involvement, and a mass could be palpated within the main stem bronchus. A routine resection of the lung was then done, each structure in the hilum being treated separately. The mediastinal pleura was sutured over the vessels and bronchial stump. The wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—"The specimen consists of the left lung with 1.5 cm. of the left main stem bronchus. In the upper lobe bronchus, arising 1 cm. from its division from the main stem bronchus, is a pedunculated mass 1 cm. in diameter by 2.5 cm. in length which projects into the main stem bronchus. The mass completely fills the lumen of the bronchus of the upper lobe and partially occludes the ostium of the lower lobe bronchus. Distally, there is a diffuse submucous tumor invasion of the bronchial wall. Hilar lymph glands and separate mediastinal glands show anthracotic pigment." Microscopic diagnosis was "carcinoma, unclassified. Lymph nodes negative."

*Convalescence* was entirely uneventful except on the fourteenth and fifteenth days when the patient had transient attacks of paroxysmal tachycardia with a pulse rate

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as high as 160. The wound healed by primary intention, and there was no evidence of a bronchial fistula. The patient was discharged on the thirty-fourth postoperative day.

*Follow-Up.*—The patient was last examined Sept. 30, 1938, almost 19 months after operation. At that time, she was symptom-free, able to do her housework, and considered herself normal in every way. Examination was negative except for a slightly contracted left hemithorax with partial displacement of the viscera to that side.

CASE 11.—S. B., female, aged 45 years, housewife.

*Symptoms.*—Chronic cough with slight, nonodorous expectoration had been present for 13 months. More recently, pain of a constant dull type was present in the right chest. Nineteen years previously she had spent 6 months in a sanatorium for treatment of pulmonary tuberculosis.

*Examination* was not remarkable except for slightly impaired resonance over the right anterior chest in its lower half and diminished breath sounds over the same area.

*Laboratory Examination.*—All routine examinations were within normal limits.

*X-ray Examination.*—"There is a diffuse area of density in the right lung field below the hilum and near the mediastinum. Bronchograms show failure of filling of the right middle lobe; otherwise are normal."

*Bronchoscopy* revealed a stenosis of the right middle lobe bronchus which was dilated. No tissue could be visualized from which a biopsy could be taken.

*Preparation.*—Pneumothorax was induced May 15, 1937. A complete collapse of the upper lobe was obtained, and the lung dropped completely from the apex of the chest. The position of the middle lobe had changed. Bronchoscopy was repeated May 25. The middle lobe orifice was visualized and a biopsy from a suspicious area obtained. The microscopic diagnosis was epidermoid carcinoma.

*Operation.*—Right pneumonectomy was performed June 10, 1937, under intratracheal cyclopropane anesthesia. A posterolateral approach was used. Mediastinal glands were found to contain no tumor tissue upon frozen section. The lung was resected without incident. Structures of the hilum were treated separately. The wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—"The upper and lower lobes are essentially normal. The middle lobe is greatly reduced in size. One centimeter from the point of origin of the second bronchus to the middle lobe there is an irregular shallow defect in the mucosa 5 mm. in greatest width and from 1 to 2 mm. deep. Distal to this lesion in the posterior one-third of the middle lobe is an abscess which discharges pus into the bronchus." Microscopic diagnosis was "early carcinoma, probably adenocarcinoma from mucous glands."

*Convalescence.*—The recovery was uneventful as far as the surgical aspect was concerned. The temperature was normal after the sixth day. A bronchial fistula did not occur, and the wound healed by first intention. During the second week, a mental condition with paranoid tendencies developed. She was permitted to leave the hospital 17 days after operation, somewhat sooner than would ordinarily be the case.

*Follow-Up.*—The patient was last heard of through her family physician in July, 1938, 13 months after operation. There was at this time no clinical or x-ray evidence of recurrence. She had gained several pounds in weight and felt much better, both physically and mentally.

CASE 12.—I. B., male, aged 51 years, brickmason.

*Symptoms.*—Starting with a cold 10 months previously, the patient had had a chronic cough, productive of a small amount of whitish sputum. During the 6 weeks

before admission, there had been fever as high as 102° F. with night sweats and substernal pain.

*Examination.*—The patient was a poorly nourished, elderly appearing man. The chest was barrel-shaped and the expansion was equal. The percussion note was hyperresonant throughout. Coarse rhonchi could be heard at the right base. Physical examination otherwise was not remarkable.

*Laboratory Examination.*—The red blood cell count was 3,700,000; white blood cell count, 17,800; hemoglobin, 67 per cent; vital capacity, 1,400 c.c. Other tests were not significant.

*X-ray Examination.*—Lung fields were normal except for slight emphysema throughout and a small area of haziness in the right lower lung field near the mediastinum.

*Bronchoscopy.*—The trachea and bronchi were found to be normal except for the right lower lobe bronchus. Just below the orifice of the sacral branch, a reddish, soft mass was found which completely occluded the bronchus. The biopsy report was "epidermoid carcinoma."

*Preparation.*—Right pneumothorax was induced Oct. 21, 1937. An 80 per cent collapse was obtained. The vital capacity after pneumothorax was found to be unaltered, the reading being 1,400 c.c.

*Operation.*—Right pneumonectomy was performed Nov. 15, 1937, under intratracheal cyclopropane anesthesia. An anterior approach was used. Enlarged mediastinal glands were removed and showed no evidence of tumor cells upon frozen section. The right lung was resected without incident after the hilar structures were ligated individually. The wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—The right lung weighed 860 gm. The tumor was found in the lower lobe bronchus 2 cm. below the line of resectoin. An abscess containing foul-smelling material was found in the lower lobe distal to the growth. Microscopic diagnosis was epidermoid carcinoma, Grade II, with negative lymph nodes.

*Convalescence* was uneventful. The preoperative temperature average of 102° F. gradually decreased and became normal on the seventh postoperative day. The patient was discharged from the hospital on the twenty-sixth postoperative day.

*Follow-Up.*—The patient was re-examined in July, 1938, 8 months after operation. He reported no cough and no expectoration, but he had failed to gain strength and had a constant sensation of heaviness in his right chest. He also complained of tenderness of the ribs on the right side. The discomfort was so great that it interfered with sleep and affected his appetite. A thorough study was made for evidence of metastatic involvement, and none was found. Dyspnea was not marked. Circulatory disturbances were lacking, and an electrocardiogram showed no remarkable change. His symptoms were explained on the basis of a slowly contracting fibrothorax which is less well tolerated on the right than on the left. Thoracoplasty has been considered and may be carried out at a later date.

CASE 13.—S. S., aged 53 years, saleswoman, Syrian.

*Symptoms.*—One year previously the patient began to raise small amounts of blood, not associated with much coughing or other symptoms. Two months later a sense of heaviness appeared in the lower part of her left chest. Occasional hemoptysis was repeated throughout the succeeding 10 months.

*Past Medical History.*—Six years previously, a resection of the cecum had been carried out for adenocarcinoma.

*Examination.*—The general physical examination was entirely negative, except for a slight diminution of breath sounds low in the axilla on the left side and the presence of an abdominal scar.

*Laboratory Examination.*—Laboratory studies were all negative.

*X-ray Examination.*—A roentgenogram 2 months after onset of symptoms revealed a diffuse area of increased density in the left lower lung field, and a later roentgenogram showed a slight accentuation of this shadow. Skeletal roentgenograms were negative.

*Bronchoscopy* was negative. Bronchography revealed a normal tracheobronchial tree except that the lingual branch of the left upper lobe bronchus failed to fill. A provisional diagnosis was made of solitary metastatic malignancy or primary carcinoma of the lung.

*Preparation.*—Left pneumothorax was induced March 17, 1938, and a 60 per cent collapse maintained. The vital capacity on March 24 was 1,425 c.c.

*Operation.*—Left pneumonectomy was performed April 11, 1938, under intratracheal cyclopropane anesthesia. A posterolateral incision was made and the pleural cavity opened. Upon exploration, a mass 4 cm. in diameter was found in the lingual portion of the left upper lobe. The surface of the lung in this region was puckered. There were no adhesions in the vicinity of the lesion, and the parietal pleura was not involved. Lymphatic glands removed from the mediastinum showed no malignant cells upon frozen section. The lung was then resected without incident, ligating the pulmonary vessels and main bronchus separately. The wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—"Left lung weighs 330 gm. Firm nodule in lower portion of upper lobe 6 cm. in diameter with a puckered area 4 cm. in greatest diameter on surface. The cut surface of the nodule is mottled gray, yellow, red, and black. Edges are poorly demarcated. Bronchi and vessels appear negative at hilum." Microscopic diagnosis was caseous tuberculosis of mediastinal lymph node and adenocarcinoma of lung, possibly metastatic from intestinal tract.

*Convalescence.*—There were no untoward developments until the eighth postoperative day when a tachycardia with a rate of 160 to 170 developed and lasted for 2 days. Fluid aspirated from the chest remained sterile, and the wound healed without interruption. The patient was discharged on the twenty-ninth postoperative day.

*Follow-Up.*—The patient was last heard from in August, 1938, 4 months after operation. There were no respiratory or cardiac symptoms, and she was continuing to gain strength and weight.

CASE 14.—S. B. H., male, aged 34 years, American, bookkeeper.

*Symptoms.*—For one year the patient had had a chronic cough, intermittent expectoration, and dyspnea. For 5 months there had been blood-streaked sputum, and more recently he had complained of pain in the left chest. Three months' bed rest treatment and repeated bronchoscopic aspirations failed to influence symptoms.

*Examination.*—Expansion of the left chest was limited; the percussion note was impaired; and breath sounds were absent over entire left chest. The remainder of the physical examination was not remarkable. Signs of metastatic disease were not demonstrable.

*Laboratory Examination.*—All studies were negative except for a white blood cell count of 16,600.

*X-ray Examination.*—Chest x-ray revealed a diffuse opacity of the left hemithorax except at the apex where a small amount of air was present in the lung. The mediastinal structures were shifted toward the involved side.

*Bronchoscopy.*—Bronchoscopic examination revealed a pedunculated tumor mass in the left main stem bronchus extending to within 2 cm. of the carina. Its surface was grayish white. The carina was not widened, and the trachea was normally mobile. A biopsy was obtained, and carcinoma simplex of a rather slow growing type was found.

Fig. 7.—Photograph of left lung (Case 14) after fixation and sectioning. The tumor originated at the bifurcation of the left main stem bronchus and completely occluded its lumen. Complete atelectasis of the lung followed which produced a density throughout the left lung field in the roentgenogram and obscured a shadow which the tumor itself might have produced. The white circumscribed area represents that portion of the tumor which had grown within the lung itself. Microscopic diagnosis was carcinoma simplex of slowly growing type.

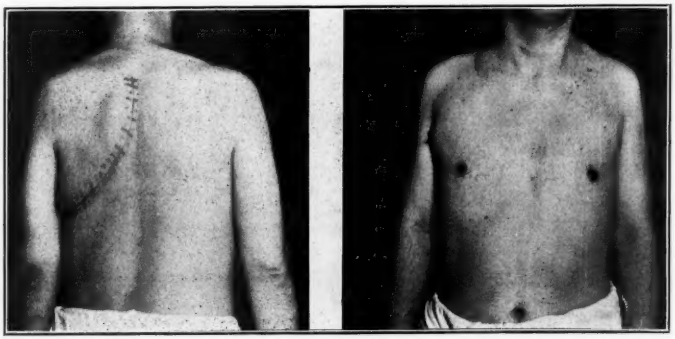

Fig. 8.—Case 14, Mr. S. B. H., aged 34 years, carcinoma simplex of left main stem bronchus. Photograph made twenty-one days after left pneumonectomy. A posterolateral approach was used. Drainage was not employed. Note lack of marked deformity and good nutrition of patient.

*Preparation.*—Left pneumothorax was induced April 12, 1938, and a 90 per cent collapse obtained. The vital capacity with the pneumothorax present was 2,700 c.c.

*Operation.*—Left pneumonectomy was performed May 6, 1938, under intratracheal cyclopropane anesthesia. A posterolateral incision was made. A tumor mass could be palpated in the hilum. Mediastinal glands were negative on frozen section. A routine resection of the lung was then carried out with individual treatment of the hilar structures. The wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—"At the bifurcation of the main stem bronchus, a well-demarcated mass of soft, mottled gray tumor tissue was found, measuring 4.5 cm. in diameter, which totally occluded both upper and lower lobe bronchi. The remainder of the lung was not remarkable. Microscopic diagnosis was carcinoma of low-grade malignancy with negative mediastinal lymph nodes."

*Convalescence.*—There were no unusual developments. A low-grade fever was present for 12 days with a pulse between 110 and 130. Following this, the temperature became normal. The wound healed by first intention, and a bronchial fistula did not develop. The patient was discharged from the hospital on the twenty-fifth postoperative day.

*Follow-Up.*—The patient was last heard from in August, 1938, 3 months after operation. He reported that he was free of all symptoms and was gaining in weight and strength consistently.

CASE 15.—D. J., male, aged 47 years, American, businessman.

*Symptoms.*—Six months previously, the patient developed a dry, hacking cough, without apparent cause. The cough became gradually more distressing and persistent. Shortness of breath appeared, and there was weight loss. There were no other significant symptoms; the sputum was negligible, and there had been no hemoptysis. Three months later a complete physical examination was made, including chest x-rays, with negative findings. More recently, an x-ray by the referring physician indicated atelectasis of the left lower lobe with pleural effusion.

*Examination.*—The patient's general condition was poor, and he presented a toxic appearance. The temperature was 102° F.; pulse, 120; respiration, 25. The findings were essentially negative, except those referable to the left chest. Expansion lagged on that side. The percussion note was diminished in the axillary region. The breath sounds were diminished posteriorly over the lower lobe.

*Laboratory Examination.*—The white blood cell count was 18,000, and there was a moderate secondary anemia. Otherwise, laboratory findings were essentially normal.

*X-ray Examination.*—A chest x-ray showed complete obliteration of left lung field, except in the upper third where the lung was partly aerated. A fluid level high in the axilla was present. The mediastinum was not displaced.

*Bronchoscopy* revealed a lesion in the left lower bronchus, which almost completely occluded its lumen. The carina was normal in appearance and the trachea mobile. Biopsy was made, and the report was as follows: "Malignant tumor, bronchiogenic carcinoma, oat-cell type."

*Preparation.*—Thoracentesis in midaxillary line yielded clear yellow fluid which was sterile upon culture, and examination of the sediment failed to show tumor cells. The patient's condition grew steadily worse with sustained fever, rapid pulse, and toxic delirium. Thoracentesis was repeated 5 days later, and the aspirated fluid was turbid and malodorous. Smear showed gram-positive cocci which later were identified by anaerobic culture as hemolytic streptococci. An intercostal catheter was inserted for closed drainage and pleural irrigation with an aqueous solution of azochloramid. Slight improvement was seen for 3 or 4 days, but then the patient began to fail again. There was evidence of extreme toxicity with delirium. The empyema cavity appeared to be adequately drained. It became evident that the

principal source of sepsis was the lung itself. Resection was decided upon since it gave the patient his only chance for recovery, with full cognizance of the poor prognosis.

*Operation.*—Left pneumonectomy was performed Aug. 18, 1938 (23 days after operation for empyema), under intratracheal cyclopropane anesthesia. The catheter drain was removed and the opening in the chest closed with adhesive tape. A posterolateral incision was made. The fifth rib was resected and the empyema cavity opened through the parietal pleura which was 2 cm. thick. Two-inch segments of the fourth, sixth, seventh, and eighth ribs were resected posteriorly before adequate exposure was obtained. The empyema cavity occupied the posterior and lateral half of the hemithorax and extended to the third rib superiorly. An incision was made in the angle formed by the adherent visceral and parietal pleura superiorly, and the upper lobe was mobilized by dissection in the extrapleural plane. Enlarged and succulent glands were found within the arch of the aorta. The glands proved to be negative for tumor cells on frozen section. A firm, irregular mass could be palpated in the lower lobe, approximately 6 cm. in diameter. It appeared to be fixed to the pericardium. By dissecting from above downward, it was possible to show that there was no apparent tumor invasion of this structure. The vessels and bronchus were separately ligated, and the lung was removed. The growth appeared to have invaded the inferior pulmonary vein, although the wall and lumen of the vein, as it emerged from the pericardium, were not involved. The vein was ligated at this point. The pneumonectomy wound was closed. The catheter drain was reinserted in the empyema sinus tract and gentle suction applied. The patient was given 2,000 c.c. of citrated blood during the course of the operation.

*Pathologic Report: Gross Specimen.*—Approximately two-thirds of the lung was covered with the visceral lining of the empyema cavity, the pleura being from 1 to 1.5 cm. thick. Upon section, an infiltrating irregular tumor 6 cm. in diameter was seen to occupy the central portion of the lower lobe. Strains of tumor tissue extended out in all directions from the hilum. The entire main bronchial wall below the dorsal branch was involved. Microscopic diagnosis was: "Carcinoma simplex, small cell; hyperplastic lymph node with anthracosis; chronic pleuritis and chronic pneumonitis, localized."

*Convalescence.*—The patient's general condition improved steadily following operation. Evidences of extreme toxicity disappeared, the temperature became normal, and the pulse gradually decreased in rate. Cough and expectoration were entirely relieved. A small bronchial fistula formed on the eleventh day but did not interrupt his progressive improvement. Four weeks after operation, the patient had a massive hemorrhage into the empyema space and died almost instantly. Autopsy revealed a mediastinal abscess which had eroded into the ligated pulmonary artery. Malignant cells were found in a lymphatic gland removed from a position adjacent to the right main bronchus.

CASE 18.—F. C., female, aged 32 years.

*Symptoms.*—For 2 years the patient had been having repeated attacks of chest pain, cough, and fever lasting from 1 to 2 weeks. The attacks were more frequent in the winter. During the previous 3 months, the cough had become more distressing and productive of a mucoid sputum which was frequently blood-tinged. There were no other significant symptoms, and there was no weight loss. Study at the Bristol County Hospital, Attleboro, Mass., failed to establish a diagnosis of tuberculosis.

*Examination* was not remarkable except for diminished breath sounds in the right anterior and lateral chest.

*Laboratory Examination.*—All tests were negative except the white blood cell count, which was 12,650. The blood sedimentation rate was within normal limits.

*X-ray.*—Chest x-ray revealed a 20 per cent collapse of the right lung (pneumothorax previously established) with slight displacement of the mediastinal structures to the left. In a position corresponding to the right middle lobe, there was a diffuse area of increased density, most marked in the center and fading out peripherally into normal appearing lung tissue. There was also a diffuse mottling in the right lung field due to previous lipiodol injection.

*Bronchoscopy* was negative. (Bronchography showed lack of filling of the bronchi of the posterolateral portion of the lower lobe and of the middle lobe.)

*Preparation.*—Pneumothorax was induced May 6, 1937, and a 75 per cent collapse obtained.

*Operation.*—Right pneumonectomy was performed June 11, 1937, under intratracheal cyclopropane anesthesia. A posterolateral incision was made. An orange-sized, solid, nonfluctuant mass was palpated within the lower lobe. The interlobar fissure was not well developed. An enlarged mediastinal gland was removed for frozen section. No evidence of malignancy was found. The history and x-ray and palpatory findings strongly suggested primary lung tumor of the peripheral type. Resection was impossible without total lung removal. Pneumonectomy was decided upon and carried out by separate ligation of the structures of the hilum. The wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—"Right lung weighing 320 gm. An indurated mass 6 cm. in diameter occupies the upper portion of the lower lobe. On section, this mass lies 6 cm. beneath the pleural surface and has a dense fibrous wall 3 mm. in thickness. It is composed of connecting cavities varying in size up to 2.5 cm. in diameter, which are filled with thick, yellow, mucopurulent material. The lining of the cavities is trabeculated and composed of soft, gray, glistening tissue. Microscopic diagnosis is localized bronchiectasis with chronic pneumonitis, fibrosis, and abscess."

*Convalescence.*—The patient required an oxygen tent for 3 days. She then continued with an uneventful postoperative course. The wound healed firmly. The bronchus remained closed, and fluid removed from the right chest was sterile upon culture. The patient was discharged on the twenty-seventh postoperative day.

*Follow-Up.*—The patient was examined Aug. 29, 1938, 14 months after operation. Her health had been perfectly good in every respect, and she was symptom-free. There had been a weight gain of 20 pounds. There was no deformity. Examination was negative except for the finding of slight diminution in the size of the right chest and abnormal physical signs on that side incident to the absence of the lung.

CASE 19.—L. Q., female, aged 25 years, housewife.

*Symptoms.*—Eighteen years previously, when 7 years of age, the patient had had pneumonia after which a chronic cough with expectoration persisted. Second and third attacks of pneumonia occurred when the patient was 13 and 15 years of age. She raised from 1 to 2 cups of sputum daily which was occasionally blood-tinged.

*Examination.*—There was marked clubbing of the fingers and toes but no cyanosis. Limited expansion of the right chest was present, with dullness to percussion throughout. Breath sounds were harsh with sonorous and moist rhonchi throughout. The left lung was negative.

*Laboratory Examination.*—Routine tests were essentially normal except for an elevated sedimentation rate. The vital capacity was 2,300 c.c.

*X-ray Examination.*—There was increased density throughout the right lung field with multiple areas of lesser density. The rib spaces were narrowed on the right side, and the mediastinum was displaced to the right.

*Bronchoscopy.*—There was a large amount of foul, purulent secretion in the right main stem bronchus which could be seen coming from the upper and middle lobes.

The lower lobe bronchus was narrowed by diffuse edema of the mucosa which obstructed passage of air but which did not prevent passage of the bronchoscope. Bronchography showed extensive saccular bronchiectasis of all three lobes of the right lung.

*Preparation.*—Artificial pneumothorax was induced and a satisfactory collapse maintained for 4 weeks before operation.

*Operation.*—Right pneumonectomy was performed July 10, 1937, under intratracheal cyclopropane anesthesia. A posterolateral incision was made. The lung was found to be densely adherent throughout, so that sharp dissection was required. The vascularity of the adhesions was great. The pericardium was opened at one point and repaired. The various structures of the hilum were dissected out, individually ligated, and the entire lung was removed. The edges of the mediastinal pleura were approximated over the stumps of the bronchus and vessels. The wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—"Cut section of the right lung shows multiple dilation of bronchi up to 2 cm. in diameter. There is considerable fibrosis throughout, with the intervening lung tissue found to be firmer than normal. Microscopic diagnosis is bronchiectasis with chronic pneumonitis and fibrosis."

*Clinical Course.*—For the first 9 days, the patient progressed satisfactorily. Fluid aspirated from the right chest showed gram-positive cocci on smear but no growth upon culture. On the tenth day, the bronchial stump opened, and the patient coughed up fluid similar to that aspirated from the right chest. A rib resection was done immediately and drainage instituted. Improvement followed.

A first-stage posterior thoracoplasty was done Aug. 11, 1937, 32 days after pneumonectomy. The upper seven ribs were resected. A second-stage posterior thoracoplasty was done Aug. 28, 1937. Posterior segments of the eighth, ninth, and tenth ribs were resected. Progress continued to be satisfactory.

Early in September, 1937, the patient began to have a series of acute episodes of abdominal pain, nausea, and fever. These attacks lasted 6 to 7 days and recurred every 10 days to 2 weeks, for a period of 3 months. The spleen was found to be enlarged and tender. A presumptive diagnosis of splenic abscess was made. On one occasion, a positive blood culture for hemolytic streptococci was obtained. Sulfanilamide was given. The last attack of fever disappeared in November, and the patient was discharged from the hospital in December, 5 months after pneumonectomy.

*Follow-Up.*—In August, 1938, 13 months after operation, when the patient was last heard of, she was free of symptoms and was leading a normal life. She had gained steadily in weight and strength. The clubbing of the fingers had partially disappeared.

CASE 20.—E. G., female, aged 10 years.

*Symptoms.*—An attack of scarlet fever 1 year before admission was followed by cough, expectoration, and weakness. For 6 months there had been intermittent fever with exacerbations of symptoms. During the past 3 weeks, the child had been hospitalized on account of a persistent high fever.

*Examination.*—The patient was a thin, pale child who appeared extremely ill. The temperature, pulse, and respiration were 101° F., 120, and 25, respectively. There were circumoral pallor, cyanosis of the lips, and clubbing of the fingers. Expansion of the right side of the chest was limited. The percussion note was dull throughout this side; whispered pectoriloquy was present, and many coarse râles could be heard.

*Laboratory Examination.*—The red blood cell count was 3,120,000; hemoglobin, 52 per cent; white blood cell count, 11,200. Sputum showed the presence of fusiform bacilli upon culture.

*X-ray Examination.*—The right chest was dense throughout, with multiple areas of varying sizes of decreased density, some showing fluid levels. The heart, great vessels, and trachea were displaced to the right. The left lung was negative. Diagnosis was multiple lung abscess involving all three lobes.

*Bronchoscopy* revealed redness and swelling of the mucosa of the right main stem bronchus without stenosis. Copious amounts of foul, purulent material welled up from each lobe bronchus on the right. The left main stem bronchus was normal in appearance.

*Preparation.*—Pneumothorax as a preliminary measure was not attempted.

*Operation.*—Right pneumonectomy was performed Nov. 13, 1937. Spinal anesthesia was employed, using pontocaine, 8 mg. (0.8 c.c.) plus 1.5 c.c. of a 10 per cent glucose solution. The anesthetic level extended to T 2. A posterolateral incision was used. After the thoracic cage was exposed, 10 c.c. of a 1 per cent solution of metacain was injected into the region of the third to the sixth intercostal nerves. The pleural cavity was opened, after resecting a long segment of the fifth rib and dividing the fourth and sixth ribs posteriorly. The lung was mobilized. Many vascular adhesions were encountered. The inferior pulmonary ligament was divided. While exposing the inferior pulmonary vein, there was a sudden cessation of both respiration and heart action. Traction on the lung and wound was released. Manual massage of the heart was given. After from 15 to 20 seconds, at first feeble, then more vigorous cardiac contractions occurred, and within 2 minutes the heart had apparently resumed its normal rhythm. The inferior pulmonary vein was then ligated and divided. No attempt was made to dissect out the other structures of the hilum. A tourniquet was applied, the lung was amputated, interrupted catgut sutures were placed in the stump, and two mass ligatures were used. The phrenic nerve was sectioned on the pericardium. A rubber tube drain was inserted below the original incision after a 1-inch segment of the eighth rib was resected. The primary wound was then closed.

*Pathologic Report: Gross Specimen.*—The specimen consists of the right lung weighing 385 gm. Multiple abscess cavities varying from 1 to 7 cm. in diameter, with walls averaging 0.3 cm. in thickness, are scattered throughout. Microscopic diagnosis is abscesses, chronic pneumonitis, and fibrosis.

*Convalescence.*—The patient responded well following operation, and there was an immediate improvement in her appearance with subsidence of toxemia. Her temperature became normal in 2 weeks. The primary wound healed without difficulty. Four weeks after operation, there was evidence of inadequate drainage of the anterior portion of the right intrathoracic space. A second drain was inserted, after resecting a segment of the fourth rib in the midaxillary line. Improvement again followed. The patient was discharged 78 days after operation with both drainage tubes in place. A thoracoplasty was not done.

*Follow-Up.*—The discharge from the lower drain gradually diminished, so that this tube was removed 3 months after operation. Evidence of a bronchial fistula had disappeared. The patient was examined Nov. 3, 1938, almost 1 year after operation, and at this time she was symptom-free. The heart and mediastinum were displaced to the right, and there was some contraction of the right chest. There was no apparent deformity. A short axillary drain was still in place and communicated with a gradually diminishing cavity, then 15 c.c. in volume.

CASE 21.—M. C., female, aged 37 years, American, housewife.

*Symptoms.*—The patient had been having repeated attacks of hemoptysis of varying severity for a period of 8 years. Severe dry coughing spells were frequent. Six years previously tuberculosis with marked thickening of the pleura was suspected, and treatment was instituted without results. Two years ago she had a

severe pulmonary hemorrhage, and since that time, she has had recurrences every 3 to 4 months, usually during menstruation. Recently, the dyspnea has been more pronounced.

*Examination.*—The patient was obese, weighing 230 pounds. There was no cyanosis, no clubbing, and no palpable lymphatic glands. Expansion of the chest was symmetrical. The percussion note on the left was hyperresonant with diminished breath sounds and an inspiratory wheeze. (A left pneumothorax had been induced before admission.) The remainder of the examination was not remarkable. No evidence of metastatic disease could be found.

*Laboratory Examination.*—Routine laboratory studies were negative.

*X-ray Examination.*—A roentgenogram of the chest revealed diffuse cloudiness of the entire left lung field.

*Bronchoscopy* showed the right bronchi to be normal. Bloody secretion was found in the left main stem bronchus. A pedunculated mass protruded into the left main stem bronchus, the origin of which was apparently from within the left upper lobe. The carina was not widened, and the trachea was normally mobile. The biopsy report was benign epithelial tumor of bronchus, "so-called adenoma."

*Preparation.*—Left pneumothorax, which had been previously induced, was maintained for 11 days. Approximately a 50 per cent collapse was obtained.

*Operation.*—Left pneumonectomy was performed March 11, 1938, under intratracheal cyclopropane anesthesia. A posterolateral incision was made. The lung was found to be densely adherent at the apex and on the mediastinal surface. A mass the size of a tangerine could be palpated at the hilum. Mediastinal glands were negative upon frozen section. Resection of the lung was then carried out, the main stem bronchus being divided 1.5 cm. from the carina. The wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—"The left lung weighed 320 gm. The pleura was thick and fibrous. A mass in the hilum, measuring $5 \times 3.5 \times 2.5$ cm., was thinly encapsulated, coarsely nodular, elastic, and pinkish gray. The walls of the upper lobe bronchus were involved in the mass. Multiple collections of turbid, mucoid, light brown material were scattered throughout the substance of both lobes. Microscopic diagnosis showed the specimen to be histologically compatible with so-called adenoma. Gross architecture suggested low-grade carcinoma."

*Convalescence.*—Moderate reaction occurred for 3 days, but her postoperative course was uncomplicated. The temperature became normal by the end of the second week, and the pulse rate gradually dropped from an average of 110 to 80. During the entire convalescence, the respiratory rate never exceeded 30 and there was never a complaint of dyspnea. It was necessary to aspirate fluid from the left chest on two occasions, 300 c.c. being obtained on the fourth day and 800 c.c. on the seventh day. Culture of the aspirated fluid showed no growth. A bronchial fistula did not occur. The wound healed normally. The patient was permitted to be out of bed on the eighteenth day and was discharged 29 days after operation.

*Follow-Up.*—The patient was examined July 28, 1938, 4½ months postoperatively. She was entirely symptom-free. She experienced no respiratory or cardiac symptoms on moderate exertion. There was no thoracic deformity. Examination showed slight contraction of the left chest with some deviation of the trachea and heart to the left. The blood pressure was 128/86; pulse, 82; electrocardiogram, normal; vital capacity, 1,800 c.c.

CASE 22.—J. M., male, aged 38 years, Swedish, truck driver.

*Symptoms.*—In 1932, pulmonary tuberculosis was discovered with complete excavation of the left upper lobe. Only after a three-stage thoracoplasty with four subsequent revisions and crushing of the left phrenic nerve on two occasions did his

sputum become consistently negative for tubercle bacilli. These operations were carried out between 1933 and 1936. During the latter year, the patient was discharged from the sanatorium and was comparatively well for 6 months. For the previous 18 months, the patient had had a progressive loss of weight and strength, progressive chronic cough with expectoration of sputum which recently had been foul, and intermittent bouts of fever usually terminating after expectoration of a large amount of sputum. The sputum had remained persistently negative for tubercle bacilli.

*Examination.*—The left chest was well collapsed by the previous surgical procedures, and the expansion was limited. Over the upper three-fourths of the left chest tactile fremitus was increased, the percussion note was dull, and the breath sounds were bronchovesicular and bronchial in quality. Moist râles and rhonchi were heard throughout the entire left chest. No significant abnormal findings were present in the right lung or elsewhere during the remainder of the examination.

*Laboratory Examination.*—Examination of the blood and urine revealed no significant abnormalities except a slight anemia and a moderate increase in the sedimentation rate. The vital capacity was 1,800 c.c.

*X-ray Examination.*—An x-ray of the chest revealed about a 90 per cent collapse of the left chest. The bronchial markings were increased in the left lower lobe. The right lung was clear.

*Bronchoscopy* revealed a stenosis of the left main stem bronchus. The narrowing began 2 cm. from the carina. No ulceration of the mucosa was seen. Bronchoscopic dilatation was attempted without benefit. Bronchography revealed slight cylindrical dilatation of the lower lobe bronchi with no filling of the upper lobe. Diagnosis was bronchial stenosis with intermittent, complete obstruction and suppuration in the lower lobe. The patient had been through an illness of 6 years and was under observation for 2 years after the pulmonary tuberculosis became inactive, yet incapacitation was complete and life was unbearable. Resection of the lung offered the only hope of relief.

*Operation.*—Left pneumonectomy was performed Sept. 15, 1938, under intratracheal cyclopropane anesthesia. A posterolateral incision was made over the fourth rib. Sharp dissection was necessary throughout the entire process of mobilization, except for that area below the hilum on the mediastinal surface. Approximately one-half of the peripheral dissection was carried out in the extrapleural and extrafascial planes. A routine resection of the lung was done with individual treatment of the hilar structures. The wound was closed without drainage.

*Pathologic Report: Gross Specimen.*—"The lumen of the bronchus to the left lower lobe was narrowed to one-third its normal size 1 cm. from the point of division. The mucosa distal to the narrowing was moderately inflamed and covered with a mucopurulent exudate, but there were no ulcerations noted. The lung substance was congested and indurated. Microscopic diagnosis was chronic bronchitis and pneumonitis."

*Convalescence.*—The patient had an uncomplicated postoperative recovery. His wound was completely healed at the time of his discharge from the hospital 24 days after operation. Two months after operation the patient was practically symptom-free and reported that there had been continuous improvement.

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# FOREIGN BODIES IN THE HEART AND PERICARDIUM—SHOULD THEY BE REMOVED?

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DELBET states that of all patients seeking surgical aid for heart injuries, 10 per cent have foreign bodies in the heart or pericardium. Several hundred reports of these cases of foreign bodies, retained for short or long periods of time, have been published in the last one hundred years, beginning with Gerard's case in 1834. In the period covering the Great War, a number of records from chiefly French and German military sources appeared. Many of these reports are meager and are undoubtedly duplicated statistically by various authors. We have reviewed 109 cases of foreign bodies in heart and pericardium reported since 1900, and they are classified as follows: bullets, 63 cases; shrapnel, 22; needles, 18; miscellaneous, 6. These include 23 cases of migrating foreign body. Nine of these foreign bodies passed out of the heart to the arterial circulation, so that, actually, only 100 reports are concerned with retained foreign bodies. The series is summarized in Tables I and II.

The vital interest attached to foreign bodies in the heart is concerned with treatment. Should the foreign body be removed or not, and when should the operation be undertaken ? Do results justify removal? It is the purpose of this paper to try to answer these questions in the light of past clinical and surgical experience.

Our own interest in the subject was aroused by the following case of a bullet lodged in proximity to the pericardium, which assumed some medicolegal importance and in which the clinical picture simulated that of a cardiac foreign body.

V. P., male, aged 29 years, was held up in a taxicab in January, 1929, and shot at a distance of about five feet. He was found to be in a state of considerable shock. The bullet had penetrated the seventh left costal cartilage 2 to 3 cm. from the midsternal line. X-ray examination disclosed its position at about the central part of the diaphragm in the vicinity of the pericardium. There was no fluid in either the pericardium or the pleura. The bullet did not move with the diaphragm. It did move with the heartbeat. The outline of the heart was normal. The patient had an uneventful convalescence from the acute injury. Except for a dry cough and local tenderness in the wound when he took a deep breath or coughed, he had no symptoms. His temperature did not exceed 100° F. Pulse range was from 90 to 100; respirations, 20; blood pressure, 120/80. Electrocardiogram showed no essential abnormality in heart action. Vital capacity maximum was 3180 c.c., about 85 per cent of normal. Re-examination by x-ray in March, 1929, showed the bullet

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to be about 3 inches below the skin, about 2 inches below the level of the top of the right leaf of the diaphragm, a little to the left and opposite the body of the eleventh dorsal vertebra, in close proximity to the heart shadow, but not definitely in the pericardium.

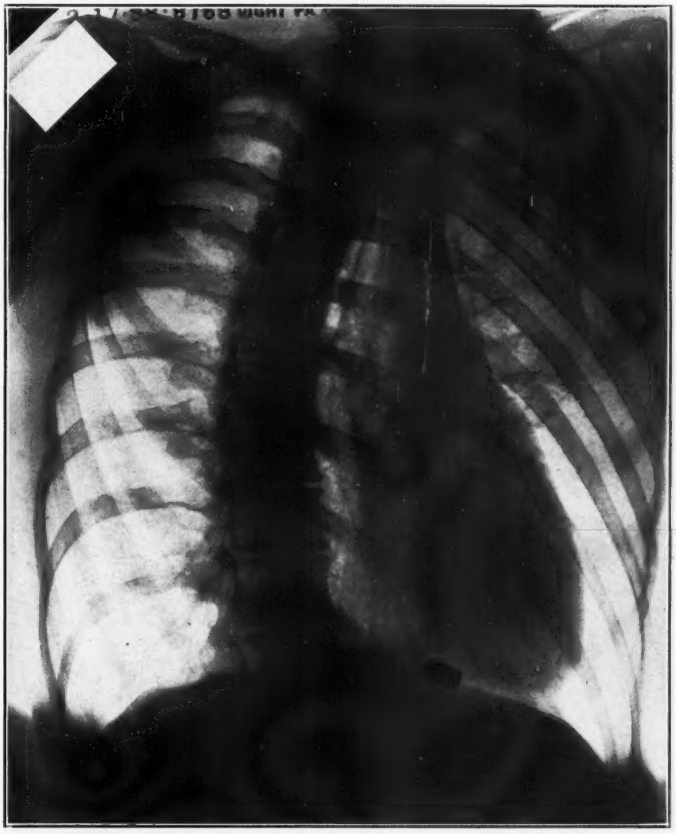

Fig. 1.—Roentgenogram showing extrapericardial bullet described in case report.

In the spring of 1929, he made numerous attempts to return to work, at first as telephone operator and later as taxi driver. He was not able to continue employment because of the following symptoms: pain in the heart region, of a pressure type and especially at night; palpitation, which would come on at any time, day or night, whether exercising or resting, recurring at least once or twice a week; dizzy spells at any time during day and night; dyspnea on exertion, such as climbing stairs and hurrying up the street; nervousness; and sweating.

These symptoms gradually ameliorated in the next two years, in which time, with the money received as compensation, he bought and ran a small delicatessen shop. He then moved to California, where he obtained regular employment as an automobile mechanic. In February, 1938, he was examined by Dr. F. S. Dolley of Los Angeles, who reported that he had no symptoms of thoracic or abdominal derangement. X-ray

examination at the Good Samaritan Hospital showed the bullet to be in practically the same anatomic position as in March, 1929. It was overlying the vertebral shadow at the level of the tenth dorsal vertebra, midway between the anterior abdominal wall and the spine. Under the fluoroscope, during easy respiration, or at the end of expiration, the bullet could be seen bobbing up and down with the cardiac impulse and lying transversely across the body. At the end of deep respiration, however, the bullet quickly changed its position, so that it lay diagonally from the right downward and outward toward the left, and the motion imparted to it by the cardiac cycle was comparatively small. It seemed to Dr. Dolley that the bullet was actually in a pad of fat between the pericardium and the diaphragm, rather than buried in the pericardium itself.

Cardiovascular examination by Dr. Weinberg revealed that the heart was long and narrow and in keeping with the ascetic habits of the patient. It was not enlarged. The point of maximal impulse corresponding to the apical retraction was in the sixth interspace, 7 cm. to the left of the midline. Venous pressure was not increased. Broadbent's sign was absent. In lateral right and left recumbency, the position of the heart shifted apparently normally. On auscultation the sounds were clear and of good quality. $A_2$ slightly greater than $P_2$. No murmurs or friction rubs were heard. Radial pressure was equal and regular. Rate was 68. Blood pressure was 130/84 on the right side with the patient in a sitting position and 126/88 on the left side. Heart measurements following percussion were normal. After exercise, hopping on one foot for one-half minute, the pulse rate was 86 at the end of one minute and returned to normal after two minutes—a normal response.

The cardiovascular system seemed normal. The foreign body did not cause any pericarditis evident on this examination.

*Summary.*—This case of bullet lying close to the diaphragm and pericardium is of interest, then, because symptoms, at first sufficient to disable the man completely from gainful occupation, cleared up entirely and have been absent for a period of seven or eight years. Removal of the foreign body was recommended at first on account of a marked psychoneurosis. Of course, now no need for removal exists, and probably will not at any future time.

Foreign bodies found in the heart and pericardium have been of three types:

1. Metallic bodies, including needles, safety pins, nails, iron pegs, hairpins, bullets, shrapnel, skewers, aluminum pipe stem.
2. Wooden bodies, such as splinters, thorns, toothpick.
3. Bony material, such as bone itself, teeth, and dental plates.

The portal of entry has usually been through the chest wall, less commonly through the blood stream, and occasionally through the esophagus or the bronchial tree. The foreign body lodges within the pericardium, the wall of the heart, or a heart cavity. If it reaches a cavity, it may lie loosely or migrate into the vascular tree of the pulmonary artery or aorta. A foreign body introduced into the wall of the heart tends to become encysted with fibrous or calcareous tissue. This same walling in may take place for a body originally loose in the cavities. Foreign bodies of migrating type are of two classes: first, those which enter the right auricle by way of the inferior cava or superior cava, following wounds of neck, abdomen, or extremities; second, those which first enter one of the peripheral vessels. Cases of

embolism to the subclavian, axillary, femoral, and iliac arteries have been reported. Once implantation in the heart has taken place, changes occur in the adjacent pericardium, myocardium, or endocardium. These may be in the nature of a simple thickening but more often are a true inflammatory reaction. When a foreign body comes into the heart from the esophagus or bronchial tree, there will almost certainly be an adhesive pericarditis. There is always a possibility of an abscess forming at the site of the foreign body, but this is a rare occurrence. Since injured cardiac muscle does not regenerate, repair is by fibrous connective tissue. If the scar is not strong enough to withstand intracardiac pressure, an aneurysm of the heart wall forms. Loisson has reported nine ruptured aneurysms in 254 cases of heart injury. The right ventricle is the most frequent place for lodgment of the body, the left ventricle next, then the pericardium, right auricle, and left auricle. At times, the foreign body is caught in the valves, in the columnae carneae, or in the interventricular or interauricular septum.

*Symptomatology* in these patients varies. A very sizeable percentage have no symptoms at all, and the condition is not recognized or is found only at autopsy after a fatal illness not related to the heart injury. In a second group early symptoms ameliorate and finally become quiescent. A third group is at first relatively free from symptoms and then develops marked manifestations. Some of these individuals, in turn, again become symptom-free. Symptoms are due to irritation of the pericardial or myocardial nerves, or to organic changes set up in the endocardium, myocardium, or pericardium, or finally to a neurosis induced by the accident and knowledge of the presence of foreign body.

As in our reported case, four subjective symptoms stand out—pain, dyspnea on exertion, asthenia, and neurotic manifestations. *Pain* is retrosternal or precordial or is often referred to the shoulder. It is likely to be deep-seated, is frequently described as a sense of weight or oppression, but may be sharp and lancinating. It is likely to be recurrent and periodic, but may be continuous. It may be intensified by exertion or by change of position. Some individuals have it only when lying down. *Dyspnea* is present usually only on exertion. Cyanosis or other symptoms referable to respiratory tract are rare and are present only if there is cardiac failure. The *general condition* varies with degree of tolerance. It may be excellent throughout. At other times, the patient is asthenic and anemic and easily fatigued. *Neurotic manifestations* are of varying degrees and character. There are often attacks of palpitation or syncope. Occasionally an individual has a sense of impending death not unlike that found in coronary disease. Rarely unusual symptoms develop as in a case reported by Sowiakowski in which there was persistent recurrent epistaxis and hemoptysis until a bullet was removed from the heart. Any or all of these symptoms

TABLE I

FOREIGN BODY REPORTS, 1900-1938

| AUTHOR | YEAR OF REPORT | FOREIGN BODY | LOCATION | DURATION | REMOVED | RECOVERED | NOT REMOVED | SYMPTOM-FREE | FOUND AT AUTOPSY | DIED |
|---|---|---|---|---|---|---|---|---|---|---|
| Birkbeck and Lorime | 1915 | Bullet | Rt. ven. | 8 days | x | | | | | 1½ days postoperatively; pneumonia and infarction |
| Beullet and Couteau | 1915 | Bullet | Rt. ven. | 8 mo. | x | | | | | 2 days postoperatively; pneumonia |
| Jenckel | 1916 | Bullet | Rt. ven., posterior wall | 12 mo. | On 2nd attempt | x | | | | |
| Ballance | 1917 | Bullet | Rt. ven., columnae carneae | 5 mo. | x | | | | | Sepsis |
| Hartman | 1917 | Bullet | Rt. ven., posterior wall | 8 mo. | x | x | | 2 yr., 9 mo. | | |
| Dujarier | 1917 | Bullet | Rt. ven., anterior wall | 22 mo. | x | x | | | | |
| Armstrong | 1917 | Bullet | Pericardium | 5 days | x | x | | | | |
| LeFort | 1917 | Bullet | Rt. ven. | 30 mo. | x | x | | | | |
| LeFort | 1917 | Bullet | Left aur. | 3 mo. | x | | | | | 4 days postoperatively; suddenly |
| Devergey | 1917 | Bullet | Left ven. | 7 mo. | x | x | | 1 mo. | | |
| Couteau and Beullet | 1917 | Bullet | Rt. aur., free | 5½ mo. | | | x | x | | |
| Chavet and Loisiles | 1917 | Bullet | Rt. ven. | | | | x | x | x | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Esconde and Brocq | 1917 | Bullet | Left ven. | 29 mo. | | | x | Some precordial distress; dyspnea on exertion | | |
| Pezzi | 1917 | Bullet | Rt. aur., free | 12 mo. | | | x | x | | |
| Deplas and Chevalier | 1918 | Bullet | Left ven., anterior wall | 3 hr. | | | x | | x | Hemorrhage into pericardium and pleura |
| Gaudier | 1918 | Bullet, 42 × 7 mm. | Left ven. | 3 mo. | x | x | | 33 days | | |
| Debeyre | 1918 | Bullet | Rt. ven., free | 5 wk. | | | x | ? | | ? |
| Duval | 1918 | Bullet | Rt. aur., free, inferior cava | 7 days | x | x | | | | |
| Menuet | 1918 | Bullet | Rt. ven. | 2 days | | | x | | x | Associated injuries |
| Pizano | 1918 | Bullet | Rt. ven. | 34 days | | | x | | x | Septicemia; wound infection |
| Swearingen | 1919 | Bullet | Left. ven. | 4 yr. | | | x | 4 yr. | | |
| Rouvillois | 1919 | Bullet | Rt. ven., apex | 4½ yr. | x | x | | | | |
| Barbier | 1919 | Bullet | Rt. ven. | 23 days | x | x | | | | |
| Burgess | 1920 | Bullet | Left ven. | 5 yr. | x | x | | 13 yr. | | |
| Proust | 1920 | Bullet | Pericardium | | x | x | | 10 yr., plays football | | |
| Luckett | 1920 | Bullet, 32 cal. | Rt. ven. | 8 days | x | x | | | | |
| Lower | 1920 | Bullet | Pericardium | | | | x | | | |
| Hayes | 1921 | Bullet | Left ven., posterior wall | Few mo. | | | x | 5 yr. | | |
| Boelkel | 1921 | Bullet | Pericardium encysted | 6 wk. | x | x | | | | |

TABLE I—CONT'D

| AUTHOR | YEAR OF REPORT | FOREIGN BODY | LOCATION | DURATION | REMOVED | RECOVERED | NOT REMOVED | SYMPTOM-FREE | FOUND AT AUTOPSY | DIED |
|---|---|---|---|---|---|---|---|---|---|---|
| Koch | 1921 | Bullet | Left. ven. | 5 yr. | | | x | 5 yr. | | |
| Schneider | 1921 | Bullet | Left ven. | 2 mo. | x | x | | | | |
| Thole | 1921 | Bullet | Rt. ven. | 15 mo. | x | | | | | Pericarditis; pleuritis |
| Dietrich | 1921 | Bullet | Rt. ven. | 4 wk. | x | x | | | | |
| Cases cited by Koch: Freund | 1921 | Bullet | Apex | | | | x | x | | |
| Fielez | 1921 | Bullet | Ventricular apex | 5 mo. | | | x | x | | |
| Niklas | 1921 | Bullet | Left ven. | | | | x | x | | |
| Heller | 1921 | Bullet | Left ven. | 6 mo. | | | x | Palpitation; intermittent dyspnea | | |
| Glaser and Kaestle | 1921 | Bullet | Rt. ven. | 1 yr. | | | x | Pain in shoulder; dyspnea | | |
| Gruber | 1921 | Bullet | Left ven. | 2 mo. | | | x | x | x | Intercurrent disease |
| Schutze | 1921 | Bullet | Left ven. | | | | | x | | |
| Pick | 1921 | Bullet | Rt. ven. | 2½ yr. | | | x | x | | |
| Schutze | 1921 | Bullet | Left ven. | | | | x | x | | |
| Muhsam | 1921 | Bullet | Ventricle | | | | x | x | | |
| Tecon, H. | 1922 | Bullet | Left ven. | 2 yr. | | | x | After 8 mo. able to climb 2,000 meters | | |
| Grigsby | 1922 | Bullet | Pericardium | | | | x | x | | |
| Davison | 1923 | Bullet | Pericardium | 2 mo. | x | x | | x | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Shaw and Cunningham | 1924 | Bullet | Rt. aur. | 60 days | | | x | x | | |
| Steckbauer | 1925 | Bullet | Rt. ven., 22 cal. | 9 mo. | | | x | 9 mo. | | |
| Allen | 1927 | Bullet, 48 cal. | Pericardium | | x | x | | | | |
| Birt | 1928 | Bullet | Rt. ven. | 4 wk. | Op. not found | x | Discharged spontaneously | Dyspnea | | |
| Hentz | 1929 | Bullet | Pericardium | 10 yr. | | | x | 10 yr. | | |
| Shoemaker and Eckels | 1930 | Bullet | Rt. ven. | | | | x | x | | |
| Cutler | 1935 | Bullet | Pericardium | 52 yr. | | | x | x | | |
| Ferrabro and Trial | 1935 | Bullet | Rt. ven. | 27 yr. | | | x | x | | |
| Sowiakowski | 1936 | Bullet | Left ven. | 3 mo. | x | x | | x | | |
| Christeson | | Bullet | Rt. ven. | 2 yr. | | | x | x | | Pleurisy |
| Beaussanet | 1915 | Shrapnel, 1.5 gm. | Rt. ven. | 11 mo. | x | x | | | | |
| Loubligeois | 1916 | Shrapnel ball | Left ven., free | 2 mo. | | | x | | | |
| Bichat | 1916 | Shrapnel fragment | Rt. ven., free | 20 days | x | x | | | | |
| Skirving | 1917 | Shrapnel, 2 × 1.5 cm. | Pericardium | 6 mo. | x | x | | | | |
| Delbet | 1917 | Shrapnel, 3 cm., 14.5 gm. | Rt. ven. | 2½ mo. | x | 5 mo. | | 5 mo. | | |
| LeFort | 1917 | Shrapnel | Left aur. | | Op. not removed | | | | | |

TABLE I—CONT'D

| AUTHOR | YEAR OF REPORT | FOREIGN BODY | LOCATION | DURATION | REMOVED | RECOVERED | NOT REMOVED | SYMPTOM-FREE | FOUND AT AUTOPSY | DIED |
|---|---|---|---|---|---|---|---|---|---|---|
| Vouzelle | 1917 | Shrapnel fragment; free | Left ven. | | | x | x | x | | |
| Esconde and Borcq | 1917 | Shrapnel, small | Apex | 19 mo. | | 19 mo. | x | 19 mo. | | |
| Lyle | 1917 | Shrapnel, shell fragment | Rt. ven., free | 4 days | | | | | x | Gas bacillus infection |
| Ponzio | 1918 | Shrapnel | Rt. ven., free | 12 mo. | | 1 yr. | x | 1 yr. | | |
| LeFort | 1918 | Shrapnel fragment, 8 × 4 mm. | Left ven. | | | | | | | |
| McCartney and Drummond | 1918 | Shrapnel | Rt. ven. | 36 hr. | | | | | x | Shock; hemorrhage |
| Bland-Sutton and Ritchie | 1919 | Shrapnel, 2 cm. × 1.2 cm. thick | Rt. ven. | 5 days | | | x | | x | Sepsis, 5 days |
| Koch | 1921 | Shrapnel | Rt. Ven. | | | 4 yr., 9 mo. | x | 4 yr., 9 mo. | | |
| Becker | 1921 | Shrapnel, pea-sized | Apex | 6 mo. | | | x | Palpitation, dyspnea | | |
| Hagentorn, J. | 1922 | Shrapnel, pea-sized | Rt. aur. | 5 yr., 2 mo. | x | x | | Back to fight in 3 mo. | | |
| Bascia | 1923 | Shrapnel | Rt. aur. | | | | x | 2 yr. | | |
| Lockwood | 1929 | Shrapnel, 1.2 cm. | Pericardium | 10 hr. | x | x | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Lockwood | 1929 | Shrapnel, 1 cm. × 1 cm. | Left ven. | 14 days | Op. not removed | | | 5 yr. | | |
| Straight and Wood | 1929 | Shrapnel, ½ size little fingernail | Rt. ven., chordae tendineae | 1 day | Op. not found | | | | | Pericarditis, 5 days postoperatively |
| Risel | 1910 | Needle, 3 fragments | Rt. ven., apex | 15 yr. | | | x | x | | |
| Magnan | 1911 | Needle | Tricuspid valve through interventricular septum | | | | x | | | Pneumonia |
| Mott | 1912 | Needle, ¾ in. | Interventricular septum | 29 yr. | | | x | 29 yr. | x | |
| Northrup | 1913 | Needle, 2 in. | Left ven., through mitral valve | 1 yr. | | | x | | | Bronchopneumonia |
| Lipososky | 1913 | Needle | Left ven. | | x | x | | | | |
| Leriche | 1916 | Sewing needle | Left ven. | 3 days | x | x | | x | | |
| Cope | 1920 | Sewing needle ⅝ in. | Left ven. | 1 day | x | x | | | | |
| Meyer-Pantin | 1920 | Needle, 4.3 cm. | Left ven. papillary muscle | | | | x | x | x | Tuberculosis |
| Fiori | 1926 | Needle, 5 cm. | Rt. ven. | | x | x | | 9 mo. | | |
| Hinton | 1929 | Explor. needle | Left ven. | 7 days | | | x | | x | Hemopericardium |
| Nehrkorn | 1929 | Needle, 1 in. | Left ven. | 1 day | Op. not removed | x | | x (Removed intercostal sp. 3 wk. later) | | |
| Dreiling | 1933 | Darning needle | Pericardium | 5 days | x | x | | | | |

TABLE I—CONT'D

| AUTHOR | YEAR OF REPORT | FOREIGN BODY | LOCATION | DURATION | REMOVED | RECOVERED | NOT REMOVED | SYMPTOM-FREE | FOUND AT AUTOPSY | DIED |
|---|---|---|---|---|---|---|---|---|---|---|
| Rea-Hoover | 1934 | Needle, 3.4 cm. | Rt. ven. | 3-4 yr. | | | x | | x | Perforation; hemothorax; lung collapsed |
| Goldberger and Clark | 1934 | Needle, 1¾ in. | Left ven. | 24 hr. | x | | | | | 14 hr. postoperatively; heart tamponade |
| Burlein | 1934 | Needle | Rt. ven. | 4 hr. | x | x | | | | |
| Fair | 1935 | Darning needle, 3 in. × ⅛ in. | Left ven. | | Op. not found | x | x | x | | |
| Scrimger and Eakin | 1935 | Needle, 7 cm. | Left ven. | 5 mo. | x | x | | 3 yr. | | |
| Williams | 1937 | Needle, ¾ in. | Rt. ven. | 5 hr. | x | x | | x | | |
| Bernard | 1907 | Nail | Rt. aur. | (?) | | | x | | x | Pulmonary infarction |
| Bailey, C. H. | 1913 | Wooden toothpick | Rt. aur. | 18 days | | | x | | x | Hemorrhage |
| Braul, T. | 1927 | Dental plate | Pericardium | | | | x | | x | Pericarditis |
| Patterson | 1929 | Safety pin 6.8 cm. | Left aur. | 18 mo. | Op. not removed | | x | | x | Suicide |
| Hunter et al. | 1929 | Aluminum pipe stem, 8.9 cm. | Left ven., lung | 10 days | | | x | | | Pericarditis |
| Tees | 1934 | Fragment of drill | Rt. ven., apex | 4 mo. | | | x | Precordial pain at first; well for 1 yr. | | |

may produce invalidism so that the person is not able to do any work. A large percentage, however, are able to carry on their normal activities and even do hard manual labor, such as heaving coal as reported by Koch and climbing mountains of 2000 meters as in Tecon's case.

*Objective symptoms* may be either present or absent. They may be absent even when subjective signs are noticeable. In general, their appearance and persistence are dependent upon the amount of damage done to anatomic structures, particularly the coronary blood vessels and the auriculoventricular bundles of His. Heart action may be regular or irregular. Rate is often increased, particularly on exertion. Heart sounds may be muffled. There may be either frank auricular fibrillation or signs of heart block. The electrocardiogram may be normal or may show variations from normal indicative of coronary or auriculoventricular bundle interference. For example, the Pardee curve may be replaced by inversion of a T wave which ultimately returns to normal; there may be a persistent inversion of the T wave, a T wave diphasic in all leads, a P wave diphasic in all leads, or extrasystoles at long intervals.

While subjective symptoms and examination of the heart taken with the history of an accident may suggest the presence of a foreign body in the heart or pericardium, the diagnosis is established with certainty only by finding the body on x-ray examination. At times, small objects are difficult to see even on x-ray films, and some materials which are not particularly opaque, such as aluminum and wood, will not be located. The criterion that a foreign body is intracardiac dictates that the mass shall lie within the cardiac shadow, shall move synchronously with the heartbeat, following the movements of the corresponding muscle and independent of the movement of the diaphragm. With the fluoroscope, free bodies within the cavities are often seen to whirl around in the blood stream in a rapid and irregular fashion.

The important question to be decided in these patients with foreign bodies present is whether to attempt a removal by surgical operation or to pursue a course of watchful waiting and to intervene only if disabling symptoms develop. Some surgeons, for example Zesar, Coutard, and Leriche, take the position that all foreign bodies must be removed on account of their potential danger. They are in a distinct minority. The majority believe in a conservative plan and delay operation until the heart shows the intolerance of the body by grave subjective or objective symptoms. Reasons for conservatism are, first, that the operation is usually a hazardous one and carries, in itself, a mortality of from 10 to 20 per cent; second, there is no

TABLE II

MIGRATING FOREIGN BODIES

| AUTHOR | FOREIGN BODY | YEAR OF REPORT | POINT OF ENTRANCE | ROUTE | POINT OF ULTIMATE LODGMENT | OPERATION | RESULT | CAUSE OF DEATH |
|---|---|---|---|---|---|---|---|---|
| Schloffer | Bullet | 1903 | Thorax | Heart | Left axillary, 10 wk. | x | W* | |
| Denke | Bullet | 1916 | Thorax | Left. ven. | Rt. subclavian | x | Death | Hemorrhage; sepsis |
| Maffi | Bullet | 1917 | Base thorax, 5th rib | Inferior cava, hepatic vein | Rt. pulmonary artery | | Death | Embolism, 4 days post-injury |
| Pezzi | Bullet | 1917 | Left iliac crest | Left iliac vein, inferior cava | Rt. aur. | | W 12 mo. | |
| Debeyre | Bullet | 1918 | Rt. lumbar | Inferior cava | Rt. ven. | | ? | |
| Duval | Bullet | 1918 | Thorax | Left ven. septum | Rt. aur. | x | W | |
| Menuet | Bullet | 1918 | Lower thorax | Inferior cava, hepatic vein | Rt. ven. | | Death | Associated leg injuries, 2 days |
| Pizano | Bullet | 1918 | Thorax, left scapula | | Rt. ven. wound infection | Thoracentesis | Death | Septicemia, 34 days |
| Fry | Bullet | 1919 | Iliac region | To iliac artery and vein | Pulmonary artery | | Death | Streptococcus infection, 12 days |
| Perdoux | Bullet | 1919 | Thorax | Left ven. | Left iliac artery | x | W | |

*W = Well.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Moore | Bullet | 1920 | Thorax | Rt. ven. | Bifurcation in pulmonary artery | | Death | Embolism, 3 hr. |
| Shaw and Cunningham | Bullet | 1924 | Neck | Internal jugular vein | Rt. aur. | | W | 60 days |
| LaRoque | Bullet | 1926 | Thorax | Left ven. | Femoral artery | x | W | |
| Bichat | Shrapnel | 1916 | Rt. lower limb | Inferior cava | Rt. ven., free | x | W | |
| Grandgerard | Shrapnel | 1916 | Thorax below left clavicle | Rt. aur. 1 hr. later | Rt. iliac vein, 7 min. later | x | W | |
| Ponzio | Shrapnel | 1918 | Rt. iliac | Inferior cava | Rt. ven., free | | W 1 yr. | |
| McCartney and Drummond | Shrapnel | 1918 | Liver | Hepatic vein, inferior cava | Rt. ven. at autopsy | | Death | Shock, 36 hr.; hemorrhage |
| Bland-Sutton and Ritchie | Shrapnel | 1919 | Thorax | Inferior cava | Rt. ven. | | Death | Sepsis |
| O'Neil | Shrapnel | 1919 | Thorax | Left vein | Left common iliac, ½ hr. | x | Death | Gas gangrene, 5 days |
| Straight and Wood | Shrapnel | 1929 | Liver | Hepatic vein | Rt. ven. | | Death | Pericarditis |
| Lyle | Shell fragment | 1917 | Rt. thigh | Rt. femoral inferior cava | Rt. ven. | | Death | Gas gangrene, 5 days postinjury |
| Bailey, C. H. | Toothpick | 1913 | Duodenum | Inferior cava | Rt. aur. | | Death | Hemopericardium |
| Nehrkorn | Needle | 1929 | Thorax, left | Apex | Last intercostal space | | W | Pericarditis |

certainty that removal of a foreign body will result in recovery inasmuch as anatomic alterations in the heart may have taken place. The position of the foreign body may also be a determining point as to intervention. Those readily accessible in the pericardium or the anterior ventricular walls often are much less operative hazards than those located posteriorly or in the atria. Most surgeons, however, favor early removal of the long, thin, sharp foreign bodies such as nails, needles, and wire. Foreign bodies loose in the heart chambers are considered a specific indication for removal by a certain group on account of the danger of embolism, particularly when the body is in the right heart. The real danger, then, is of sudden death from pulmonary artery obstruction. With bodies in the left heart, the danger to life is not so acute. If they are ejected into the peripheral circulation, they may be recovered more advantageously from the terminal arteries. Delorme postulates that free, rough, foreign bodies should be removed from the ventricles. Trendelenberg, however, is of the opinion that foreign bodies in chambers soon become walled off and fixed if they are not carried early to the peripheral circulation.

*Mortality* following surgery is due usually to infection, less frequently to hemorrhage and embolism, and seldom to primary or secondary cardiac failure. Freedom from symptoms postoperatively may be related to careful surgical technique, that is, the avoidance of injury to important anatomic structures such as the bundle of His and coronary vessels. Freedom from infection, in general, spells postoperative recovery and minimal morbidity due to pericardial adhesions. Pneumonia, with or without infarction, pericarditis, suppurative pleurisy, and septicemia have been responsible for death. The same factors have been lethal when no operation has been done and in similar order of importance. Causes of death in our series are shown in Table III and are evenly divided between those referable to the heart and the lungs.

TABLE III

CAUSES OF DEATH IN 27 OF 109 CASES*

| CAUSES OF DEATH | TOTAL | FOREIGN BODY | | | |
|---|---|---|---|---|---|
| | | BULLET | SHRAPNEL | NEEDLE | MISCELLANEOUS |
| Sepsis (bacteriemia) | 6 | 3 | 3 | | |
| Hemorrhage, pericardial and pleural | 6 | 1 | 1 | 3 | 1 |
| Pericarditis | 4 | 1 | 1 | | 2 |
| Pleuritis and pericarditis | 1 | 1 | | | |
| Pulmonary embolism | 2 | 2 | | | |
| Pulmonary infarction | 1 | | | | 1 |
| Pneumonia | 4 | 2 | | 2 | |
| Sudden death (cardiac) | 1 | 1 | | | |
| Associated injuries | 2 | 1 | 1 | | |
| Total no. of deaths | 27 | 12 | 6 | 5 | 4 |
| Total no. of cases | 109 | 63 | 22 | 18 | 6 |
| Percentage of mortality | 24.8 | 19.0 | 27.7 | 27.7 | 66.6 |

*Includes migrating cases where foreign body lodged in peripheral vessels.

It is to be noted that infections are responsible in fifteen cases and hemorrhage in six, in three of which shock from injury was an added factor. Operative shock may have been contributory in one case. The type of foreign body had little bearing, except that massive bodies were almost universally fatal.

TABLE IV

MORTALITY IN 109 CASES

| | BULLET | SHRAPNEL | NEEDLE | MISCELLANEOUS | TOTAL |
|---|---|---|---|---|---|
| Number of cases | 56 | 20 | 18 | 6 | 100 |
| Location of foreign body: | | | | | |
| Rt. Ven. | 24 | 9 | 5 | 1 | 39 |
| Left Ven. | 15 | 4 | 10 | 1 | 30 |
| Rt. Aur. | 4 | 2 | | 2 | 8 |
| Left Aur. | 1 | 1 | | 1 | 3 |
| Pericardium | 9 | 2 | 1 | 1 | 13 |
| Interventricular septum | | | 2 | | 2 |
| Apex | 3 | 2 | | | 5 |
| Duration | 3 hr. to 52 yr. | 5 days to 5 yr. | 3 hr. to 29 yr. | 2 days to 18 mo. | |
| Cardiac operation with removal of foreign body | 24 | 7 | 9 | 0 | 40 |
| Cardiac operation without removal of foreign body | 1 | 3 | 2 | 1 | 7 |
| Deaths | 6 | 1 | 1 | 0 | 8 |
| Postoperative mortality | 24% | 10% | 9.1% | 0.0% | 17% |
| No operation | 31 | 10 | 7 | 5 | 53 |
| Deaths, attributed to foreign body | 4 | 4 | 4 | 4 | 16 |
| Nonoperative mortality | 12.9% | 40% | 57.1% | 80% | 30% |
| *Nine Cases in Which Foreign Body Lodged in Peripheral Vessels* | | | | | |
| Foreign body removed from peripheral vessel | 4 | 2 | 1 | | 7 |
| Deaths | 1 | 1 | | | 2 |
| Postoperative mortality | 25% | 50% | 0.0% | | 28.6% |

RESULTS

Referring to Table IV, which is a summary of mortality in the cases we have reviewed, it will be seen that there were 8 deaths following a total number of 47 operations (17 per cent) as opposed to 16 deaths in 53 cases not operated upon (30 per cent). This would seem to indicate an advantage of operative interference in a proportion of almost 2 to 1. When these figures are compared with statistics gathered by other writers (Table V), there is the same average postoperative mortality, but a much higher nonoperative mortality. It is to be observed, however, that in our group not operated upon, of the 16 deaths, 6 were due to bacteriemia or to shock and hemorrhage from associated injuries, causes not specifically the result of heart damage from the foreign body. When all these series are averaged, the mortality with operation or without operation is about a standoff and in the neighborhood of 20 per cent.

TABLE V

COMPARATIVE STATISTICAL SUMMARY

| AUTHOR | YEAR | NUMBER OF CASES | OPERATIVE CASES | DEATHS | PERCENTAGE OF MORTALITY | NONOPERATIVE CASES | DEATHS | PERCENTAGE OF MORTALITY |
|---|---|---|---|---|---|---|---|---|
| DuVal | 1917 | 39 | 16 | 2 | 12.5 | 23 | 0 | 0 |
| | | 23 free | 10 | 3 | 30.0 | 13 | 1 | 7.7 |
| Esconde and LeBrocq | 1917 | 14 | 7 | 3 | 43.0 | 7 | 1 | 14.2 |
| DeLorme | 1918 | 25 | 25 | 3 | 12.0 | | | |
| LeFort | 1918 | 11 | 9 | 1 | 11.0 | | | |
| Hoffman | 1920 | 50 | 15 | 3 | 20.0 | | | |
| Syller | 1927 | 9 | 8 | 0 | 0 | | | |
| Singleton | 1932 | 86 | 33 | 4 | 19.7 | 49 | 5 | 10.2 |
| Decker | 1939 | 100 | 47 | 8 | 17.0 | 53 | 16 | 30.0 |

On the basis of statistics, therefore, one cannot argue with too much certainty for or against operation. However, it is possibly justifiable to make the following deductions from our statistical review:

1. It is relatively safe to remove foreign bodies from the pericardium.

2. It is relatively dangerous to allow sharp foreign bodies to remain in the heart on account of the tendency to perforate fatally later.

3. It is relatively dangerous to leave foreign bodies free in the right heart on account of the risk of pulmonary embolism and infarction.

4. Large foreign bodies in the pericardium lead to fatal issue and should be removed as early as practical.

5. If, in the course of an operation to remove a foreign body, unfavorable cardiac symptoms develop, it is wise to desist. One is guided as to whether or not to operate later by the course of events.

6. Intramural fixed bodies usually do not cause death, nor shorten life.

7. Removal of foreign bodies usually gives relief from symptoms complained of and due to them.

Most reports of removal of foreign bodies from the heart record only the immediate postoperative results, so that there is no substantial record to show whether the individuals who have been operated on are well and free from symptoms or ultimately have some disability. Several in our series have been observed to be well for a period of five years, and one individual lived twenty-two years following operation, free from symptoms. A few soldiers, after removal of foreign bodies, went back to fight, others to do heavy labor; several participated in athletic sports. At the same time, the injured have tolerated foreign bodies for long periods. Hentz reported one in the

pericardium without symptoms for a period of ten years; Cutler, one for fifty-two years; Mott, a case of a needle in the heart for a period of twenty-nine years; and Fenabro and Trial, a bullet in the right ventricle for twenty-seven years. Apparently, persons with the foreign body in the pericardium have the best prognosis, both immediate and ultimate; patients in whom the foreign body is in the immediate ventricular wall have the next best prognosis, and those in whom the foreign body has lodged in the auricular walls or the heart cavities have the highest morbidity and mortality. In our series of 13 patients with foreign bodies in the pericardium, 8 were operated upon without mortality. In the 5 not operated upon, there was only 1 death, which was caused by pericarditis. In 33 operations for bodies in the ventricular wall, there were 5 deaths (15 per cent), and in 3 operations for bodies in the auricular wall, there were 2 deaths (66 per cent). In 8 patients who had foreign bodies free in the heart cavities, 2 were operated upon with 1 death and 1 recovery (50 per cent). Two not operated upon died in 4 days and in 5 weeks, respectively, while the remaining 4 were well as follows: foreign body in left ventricle, 2 months; in right auricle, 5 months; in right auricle, 12 months; in right ventricle, 12 months.

Summarizing, then, published opinion and our own, based on the study of these 109 cases and undertaken to seek the answer to the proper management of foreign bodies in the heart, it may be said foreign bodies should not be removed simply because of their presence. No emergency exists in those patients who survive the original trauma, unless one chooses to consider that free cavity bodies, sharp needle-like bodies, and large objects need immediate or early surgery. As Matas says, indications for removal cannot be formulated by mere statistics. They must be based upon individual prognosis and review of the condition of the patient and the degree and duration of the disability.

# LIGATION OF THE LEFT MAIN HILUM FOR BRONCHIECTASIS WITH SURVIVAL OF THE LOWER LOBE

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SINCE the technique of pneumonectomy must be varied in certain instances to meet the conditions encountered in complicated cases and since the operation is still more or less in the developmental stage, we feel prompted to report a rather unexpected occurrence following mass ligation of the left main bronchus and vessels.

## CASE REPORT

H. S., white female, aged 19 years, entered the Buffalo General Hospital Nov. 21, 1929.

*History.*—Her history was irrelevant with the exception of numerous colds, bronchitis with cough and sore throat at frequent intervals since childhood, whooping cough in 1918, and tonsillectomy in 1921. She had had a cough as long as she could remember, but it had become increasingly severe and productive of foul expectoration during the previous year. She usually had three paroxysms of coughing during the day, each of which was productive; the most severe occurred about 11 A.M. daily. At the time of admission she had been unable to work regularly because of this complaint. The morning of Nov. 16, 1929, she developed fever up to 103° F. with chills and a dull pain in her left lower chest. She consulted a physician, who referred her to the hospital.

*Physical Examination.*—Positive findings on physical examination consisted of a limitation of expansion, dullness on percussion, diminution in tactile fremitus, and moist, bubbling inspiratory and expiratory râles, all present over the left base, both anteriorly and posteriorly. There was marked clubbing of the fingers.

*Laboratory Findings.*—Hemoglobin was 70 per cent (Newcomer); red blood cells, 4,120,000; white blood cells, 15,600; Wassermann test, negative. In the sputum were found many gram-positive streptococci, gram-positive diplococci, fusiform bacilli, spirochetes, and gram-negative small bacilli. The amount of sputum reached a maximum of 600 c.c. in twenty-four hours.

*Bronchoscopic Examination.*—Congestion in the left lower bronchus with a large amount of foul exudate was disclosed.

*X-ray Examination.*—Evidence of a mottling in the lower left chest, suggestive of bronchiectasis, was given; bronchography showed a rather marked degree of saccular bronchiectasis in the lower lobe of the left lung.

*Progress.*—Before coming to our attention, she had been treated with postural drainage and had received a series of injections of air into the pleural cavity, so that an almost complete collapse of the left lung had been produced. Following this, there was a marked improvement, the sputum being diminished to 45 c.c. daily, and she was able to work. Refills were continued until September, 1931, a period of nearly two years, when a pyopneumothorax developed. Culture of the aspirated fluid revealed long-chain streptococci, fusiform bacilli, and spirochetes.

*Operation.*—On Sept. 28, 1931, about four inches of the eighth and ninth ribs were removed in the posterior axillary line, and open drainage was instituted for

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a complete and putrid empyema. No bronchial fistula was demonstrated. Following this, the temperature dropped to normal, but re-expansion of the lung was far from sufficient and a large chronic empyemic cavity persisted. This was obliterated by a crushing of the phrenic nerve and a graded paravertebral thoracoplasty, including the eleventh rib.

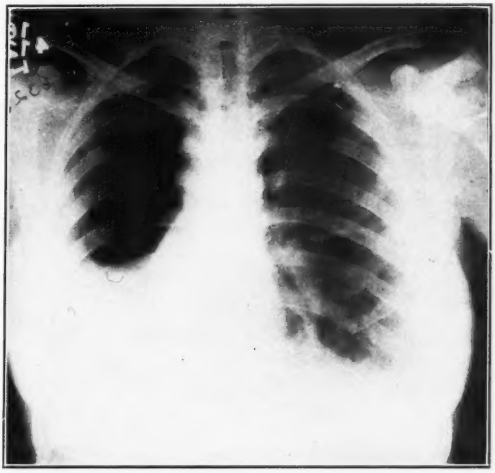

Fig. 1.—Roentgenogram showing left pyopneumothorax.

Fig. 2.—Roentgenogram showing bronchiectasis on the left side which persisted after thoracoplasty. There is also bronchiectasis in the lower lobe of the right lung.

*Progress.*—Following this, the pleural surfaces became approximated, the sinus closed, and the patient was greatly improved, having gained weight and produced no sputum except on postural drainage, which yielded 175 c.c. a day.

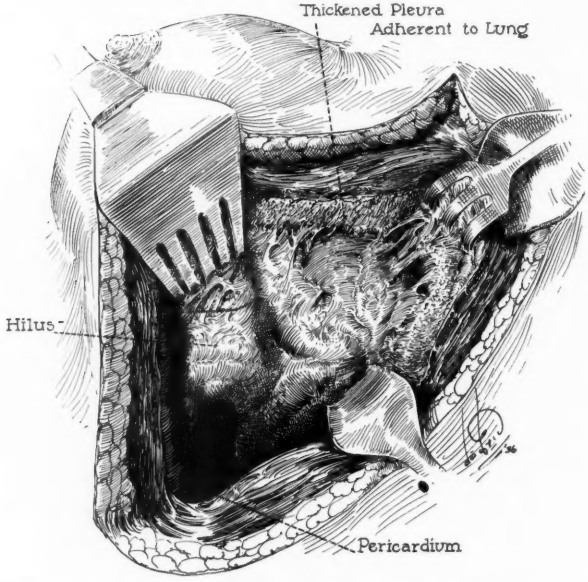


Fig. 3.—Exposure of the left main hilum through anterior incision; free space seen inferiorly. Broken line indicates site of opening above hilum.

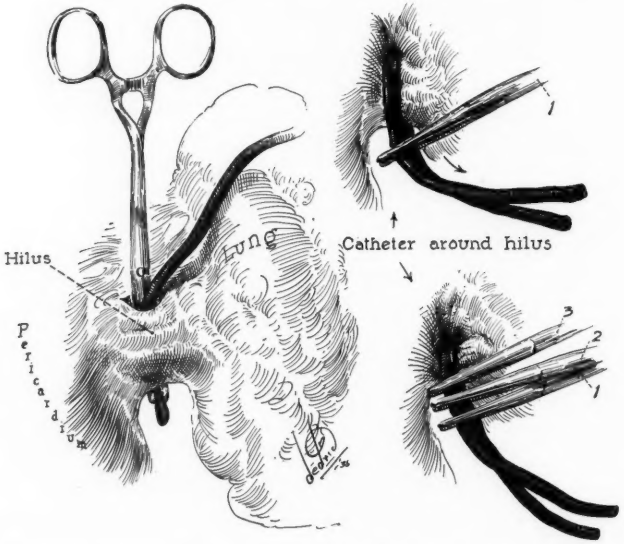


Fig. 4.—Drawing showing method of application and location of tourniquet about left hilum.

She was readmitted Nov. 7, 1932, because of the recurrence of 1½ cupfuls of sputum per day. Lipiodol injection at this time revealed marked bronchiectasis in the cardiophrenic angle on the left side, the right side showing only a very minute degree of dilatation in a few terminal bronchi. In view of the condition existing, some type of lobectomy was decided upon.

*Operation.*—On Nov. 21, 1932, structures were separated over the left lower lobe, and sufficient ribs were removed to give an adequate exposure. Dense adhesions were encountered with markedly thickened pleura. Surgical removal of the lobe seemed to be out of the question because no lines of cleavage could be established, and a cauterization of the lobe after the method of Graham[1] was decided upon. Several cauterizations were done and multiple bronchial fistulas, which exuded pus, were established. Since the patient did not withstand these procedures well, a complete destruction of the lobe was not accomplished.

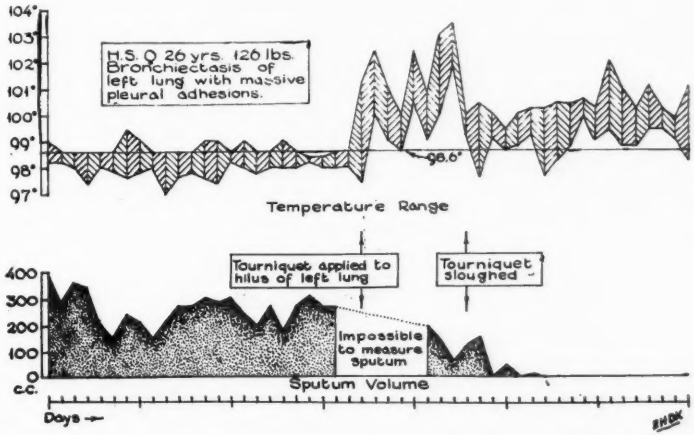


Fig. 5.—Diagram showing disappearance of sputum following ligation of the hilum.

*Progress.*—She was discharged with improvement and was able to pursue her duties as a domestic servant until she became progressively worse and was readmitted in January, 1936. At this time there was about 300 c.c. of sputum a day; there were repeated attacks of bronchopneumonia from plugging of the bronchus, and she realized, as did her family, that she was unable to carry on in her present condition. Bronchoscopic examination revealed some collapse of the left bronchus with purulent exudate coming from both lower lobes. Lipiodol injections revealed a progression of the dilatation in the right lower bronchi. In view of existing conditions, we decided upon an anterior approach in an attempt to ligate the hilum and remove the left lower lobe.

*Operation.*—On Feb. 20, 1936, under nitrous oxide anesthesia, with an intratracheal catheter for continuous suction, the left breast was elevated with the resection of the third and fourth ribs anteriorly. The pleura was extremely thick and so densely adherent to the lung that it was opened with considerable difficulty. The interlobar fissure was entirely obliterated. By carrying the finger along the pericardium, it was possible to find a free space medially between the lower lobe and the diaphragm, and the pulmonary ligament was divided. There appeared no possibility of separating the adhesions laterally, as the lobe seemed to be a part of the

chest wall. Superiorly, it was impossible to separate the lung from the mediastinum; so, by sharp dissection, an opening was made above and close to the main bronchus and a rubber catheter was introduced, completely encircling the bronchus and the vessels. This was made extremely tight with hemostats, and the wound was partially closed around a vaseline gauze pack.

*Progress.*—The patient was given a blood transfusion, and, although there was rather a marked reaction to this procedure, she survived; on the eighth day the tourniquet sloughed through and came out of the wound with the loop intact. Necrotic lung tissue was also removed periodically, and a large bronchial fistula persisted, which closed in six weeks. Following this, the sputum entirely disappeared, and she was up and about the ward and rapidly gaining in weight. Five weeks later the sputum reappeared, and on April 23, 1936, the patient died.

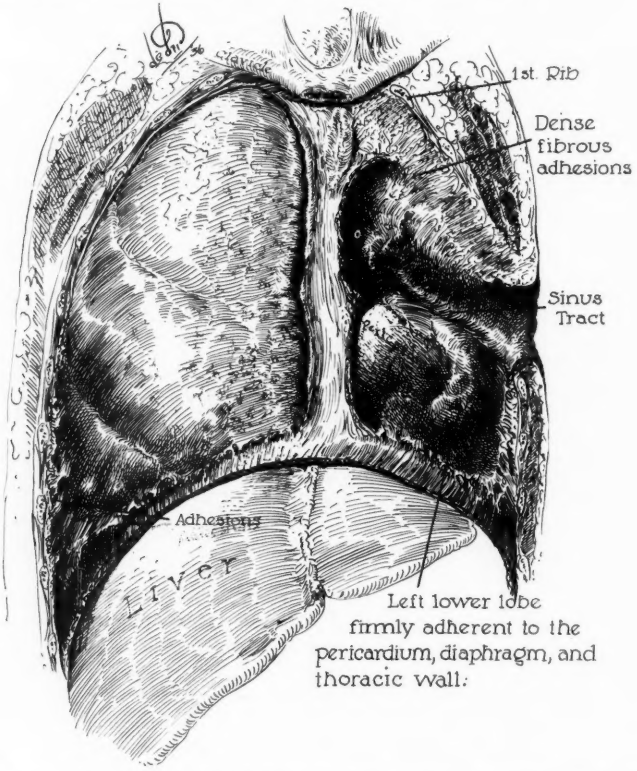


Fig. 6.—Drawing of appearance of thoracic contents at post-mortem examination.

*Autopsy.*—No. 3254. This was limited to an investigation of the chest and abdomen. The relevant findings were:

1. Cylindrical bronchiectasis of the right lower lobe with marked pleural adhesions and a lobular pneumonia of the entire right lung.

2. Complete obliteration of the left pleural cavity by fibrous adhesions and the absence of the left upper lobe.

3. Complete collapse of the left lower lobe and complete adhesions between this lobe, the diaphragm, the parietal pleura, and the pericardium. The left lower bronchus communicated between this lobe and the trachea.

4. Chronic bronchiectasis in the basal half of the left lower lobe with cavities of an average hazelnut size, chronic interstitial pneumonia, and chronic bronchopneumonia with carnification.

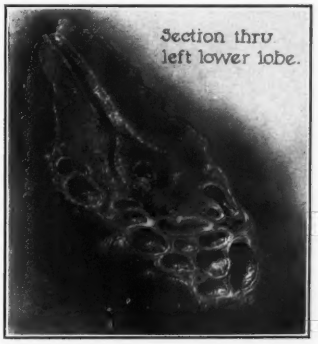


Fig. 7.—Post-mortem specimen of the left lower lobe.

## COMMENT

It is rather difficult to explain how the continuity between the left lower lobe bronchus and the trachea became re-established as noted in the post-mortem examination. This was very apparent, and no stricture could be observed. At the time of the operation the rubber tubing completely encircled the main hilum and the loop came through still intact without any disturbance of the hemostats, so that it must, of necessity, have sloughed through the main bronchus, as there is no question but that the entire hilum was included in the tourniquet at the time of the operation. Beye[7] mentions an intact bronchus to the lower lobe after extremely tight ligature about the hilum.

Sauerbruch[2] in 1922 appears to have ligated the blood supply to the entire left lung while removing a large ganglioneuroma, following which procedure, the entire lung sloughed off eight days later and the patient recovered. He mentioned, however, that the pleural cavity was entirely free at the time of the operation.

Nissen[3] in 1930 ligated the left main hilum in a 12-year-old girl suffering from bronchiectasis; fourteen days later there was a sequestrum of the entire lung, and the child recovered. It is noted in his report of this case that both the upper and lower lobes were freed previous to the application of the tourniquet.

Haight[4] in 1932 ligated the lobar hila on the left side separately, following which the upper lobe sloughed off on the sixteenth day and the lower lobe on the subsequent day. The patient recovered follow-

ing this procedure. It was also stated here that both lobes were completely freed before the ligatures were placed about the hila.

Windsberg[5] in 1932 treated a patient in whom supposed pneumonectomy was preceded by attempted destruction of the lower lobe with repeated cauterizations. At the time of pneumonectomy numerous adhesions were encountered, so that sharp dissection of the mediastinum was necessary to isolate the hilum, which was ligated and divided, and the lung was amputated. In a later article[6] he corrected the impression conveyed in his previous paper, for a mass of collapsed lung tissue, which apparently corresponded to the remaining right lower lobe, was found embedded in dense adhesions and connected with the trachea by a large bronchus. This was found at post-mortem examination, which was performed more than three years following the operation.

Beye[7] in 1933 had a case which was similar to ours, although the operation dealt with lobectomy rather than pneumonectomy. The hilum of the left lower lobe was completely encircled with a tight catgut ligature. A subsequent operation, nine months later, revealed a shrunken, adherent, and firm lower lobe persisting. It was further noted that two large vessels were seen which passed through the chest wall to the lung, one of which was estimated to be one-half the size of an ordinary lead pencil.

It was stated in this article that, at the time of the first-mentioned operation, the lobe was mobilized and ligation of the hilum was carried out with No. 4 chromic catgut, which was tied with great force. At the subsequent operation, at which time the lobe was again freed and removed, the bronchus was intact.

It seems needless to draw attention to the fairly large-sized blood vessels that are at times seen in adhesion bands during the performance of a pneumolysis. Studies on the circulation of the lung substantiate the clinical findings in the above cases and are very convincing proof that the bronchial circulation undergoes marked changes under abnormal conditions within the lung. This should be borne in mind when removal of a diseased lobe or lung is contemplated, as the end is, at times, defeated by some abnormality, the effects of which have not been sufficiently considered.

To emphasize this point, I quote from Heuer's[8] presidential address in 1934: "While the experimentalists were perfecting the ideal operation in the presence of normal conditions, surgeons were finding that conditions created by disease were so far from normal as to preclude the ideal operation. This was true to some extent of the tumors of the lung, but was particularly so of bronchiectasis."

In this instance, a precedent has not been set either by the attempt at pneumonectomy through ligation of the main hilum or by the survival of a lobe after apparent obliteration of the blood supply.

Graham[9] mentioned ligating the branches of the pulmonary artery in an attempt to produce carnification of the lung in the treatment of bronchiectasis; he referred to cases reported by Bruns and Sauerbruch and to eleven cases reported by Willy Meyer in 1914 and included a bibliography on the subject.

Mathes, Holman, and Reichert[10] produced experimental evidence to show that the nutrition of a lobe is maintained by the bronchial artery and vein with their collaterals, after ligating the pulmonary artery and vein to that lobe. These authors further stated that the changes in the lobe are more marked when the pulmonary vein is ligated with the pulmonary artery.

Wood and Miller[11] discussed the role of the dual pulmonary circulation in various pathologic conditions of the lungs and reviewed the literature on the subject. They have demonstrated dilated bronchial vessels by roentgenograms of injected specimens. Miller[12] noted that in animals with a thin pleura, such as the rat, rabbit, cat, and dog, no septa are found, and since it is in these prolongations that the branches of the bronchial artery reach the pleura, the vascular supply is different; as a consequence, this circulation is confined to a small zone in the neighborhood of the hilum in these animals, and elsewhere it is the pulmonary artery that supplies the pleura. Such is not the case in man since septa are present. As these are the more common laboratory animals, it is quite possible that some of the experimental work on pneumonectomy has been influenced by this fact.

## SUMMARY

1. It appears that ligation of the main hilum of a lung without its removal is compatible with life. This has been shown by previous cases in the literature and the one herein reported.

2. Survival of a lobe, following ligation of its main blood supply, can take place through the collateral circulation developed in pleural adhesions.

3. The bronchial circulation undoubtedly undergoes changes when various abnormal conditions exist in the lung.

4. Ligation of the pulmonary artery and vein produces distinct changes within the lung.

5. In an attempted lobectomy or pneumonectomy, when dense pleural adhesions are present, the lobe or lung should be freed if sequestration is desired.

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40 WEST NORTH STREET

# A BRONCHOSCOPIC MIRROR FOR UPPER LOBE VISUALIZATION

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THE upper lobe bronchi, often designated as "around the corner," have always been factors in the incompleteness of diagnostic bronchoscopy. Their orifices can usually be visualized and occasionally a portion of the inferior bronchial walls seen. At times, this observation, combined with clinical and roentgenologic evidence, is sufficient for diagnosis. Much more frequently one would like to peer into the upper lobe and the smaller bronchial orifices, as it is possible to do in the lower lobes.

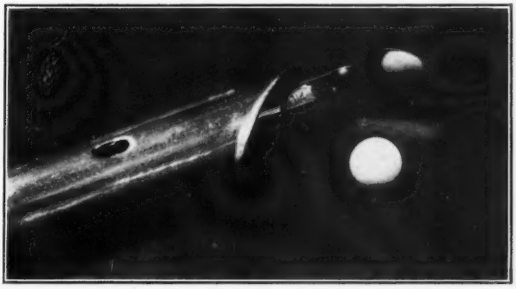

Fig. 1.—Photograph of bronchoscopic mirror attached to extra light carrier and bulb. Note image on mirror surface.

A device which would enable one to see around the corner would make diagnostic bronchoscopy a more thorough and complete procedure. A glass mirror, even if it could be made small enough, would be unsatisfactory because of the bulk of the mounting. Any shiny metal or plated surface which is highly polished will provide a good reflecting plane. This plane should be adjustable and should have a maximum surface area. The transverse diameter must be just less than that of the bronchoscope; the longitudinal diameter can be greater because of the angle of the mirror or reflecting plane. If the angle is wide, the longitudinal diameter can be increased. The shaft should be rigid and small so as not to occlude too much of the visual cross section of the bronchoscope. In addition, added illumination is helpful, for the ordinary bronchoscopic lamp affords too little. A

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rather simple device for the purpose of examining the upper lobe bronchi has been constructed and has been found useful (Fig. 1). Its novelty is not claimed, although no similar instrument is known to the author.

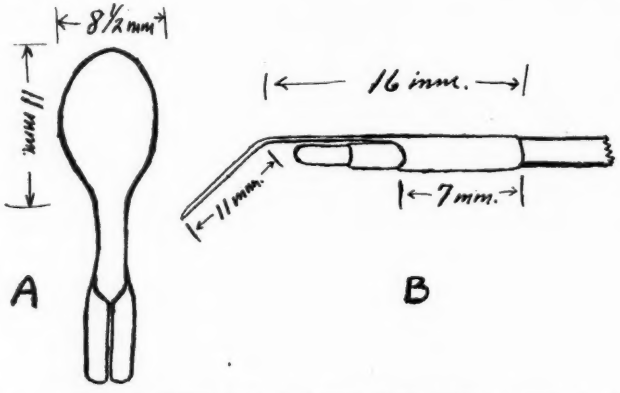


Fig. 2.—*A*, Sketch of mirror made of chrome nickel about 0.5 mm. in thickness. *B*, Side view. Mirror is slipped over an extra light carrier and tightened in place with a hemostat. The light carrier becomes the shaft and affords extra illumination.

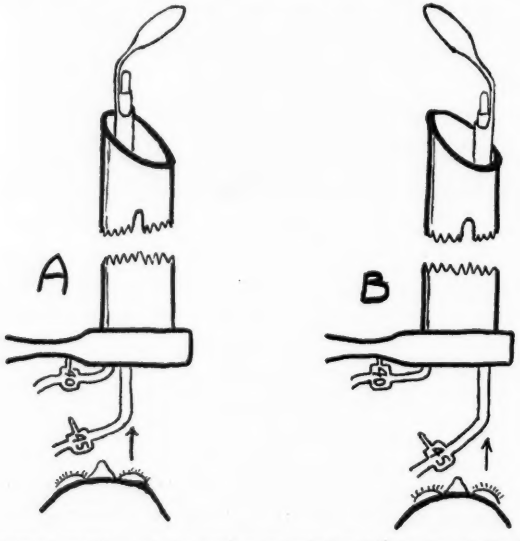


Fig. 3.—*A*, Correct position of the mirror in relation to the lip of the bronchoscope, and of the handle to the eye. *B*, Incorrect position of mirror and handle.

This mirror is made of chrome nickel and can be attached to any light carrier which then becomes the shaft (Fig. 2). It should be about 5 cm. longer than the bronchoscope to be used. The shank of the mirror is soft enough to permit bending. Thus the proper angle be-

tween shaft and reflecting plane can be obtained. Once this is done, the angle ordinarily will not have to be changed. The mirror surface reflects light into the upper lobe bronchus and displays its image.

The spur of the upper lobe should be located and the lip of the bronchoscope so placed that it appears in the lateral portion of the visible field. The bronchoscope lamp should be along the medial bronchial wall (Fig. 3). The bronchoscope is fixed in this position. One must be sure that there is space for the mirror beyond the bronchoscope (Fig. 4). Occluding secretions should be aspirated and the mirror heated above an alcohol flame before insertion. Good anesthesia is essential and quiet respiration helpful.

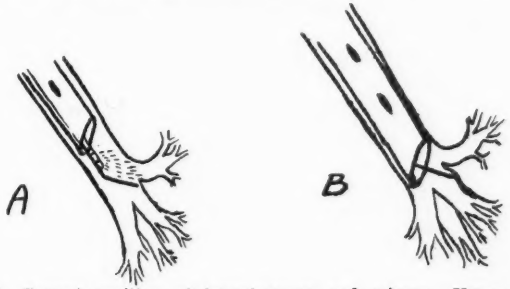


Fig. 4.—*A*, Correct position of bronchoscope and mirror. Upper lobe spur is distal to the bronchoscope but visible in the lateral portion of the field. *B*, Incorrect position. Bronchoscope is down too far; there is insufficient space for the mirror.

The shaft must be held along the light carrier channel of the bronchoscope to keep the visual cross section open. The handle of the bronchoscope and of the shaft with its cord should extend in a direction opposite that of the mirror for the same purpose (Fig. 3). The mirror is moved in and out and rotated slightly until the upper lobe orifice is located. Then, if necessary, slight readjustment may improve the view or the illumination.

The manipulation of this mirror is not easy and is at first discouraging. Practice in a rubber tube with lateral perforations and in the cadaver is of great aid.

The mirror described is for a 9 mm. bronchoscope which is not too large for adult main bronchi, but may be for work in the lower lobes. Any size mirror can be made by a metal craftsman or instrument maker. A smaller mirror may prove just as useful as the larger one in practiced hands.

# ACUTE EMPYEMA WITH BRUCELLA ABORTUS AS THE PRIMARY CAUSATIVE AGENT

## Case Report

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WHEN pus is aspirated from the chest in a case of empyema and found to contain no pyogenic organisms on smear or culture, the primary causative agent is considered to be the tubercle bacillus. The following case, therefore, is of interest:

### CASE REPORT

N. R., male, aged 25 years, university student, was admitted to hospital in the service of Dr. A. L. Anderson and Dr. J. F. C. Anderson Nov. 5, 1930. He complained of severe pain in the throat, most marked on the left side. The symptoms were accounted for by the presence of a large peritonsillar abscess, which was incised on admission. The operation was followed by some relief, although the temperature continued to fluctuate between 100 and 102° F., and the throat remained sore and inflamed. After six days he began to complain of a pleuritic pain in the lower left chest, and he felt considerably worse with a septic temperature and a pulse rate varying between 100 and 120 per minute. The presence of fluid could be demonstrated in the base of the pleural cavity on the left side by physical examination. This was confirmed by x-ray.

Aspiration of the left chest was performed November 21, and thin purulent fluid was obtained. Examination showed it to contain numerous leucocytes, chiefly polymorphonuclear, and a few lymphocytes. No organisms were demonstrable either in the smear or by culture. Examination for the tubercle bacillus was negative.

To relieve toxemia and respiratory embarrassment, aspiration of the fluid was done at two- to three-day intervals between Nov. 21 and Dec. 9, 1930. The amounts withdrawn varied between 200 and 500 c.c., and the fluid became more purulent with each aspiration. Following the aspiration on Nov. 29, examination of the smear demonstrated gram-negative diplobacilli. No growth was obtainable, however, on a blood agar medium. At this time it was learned that a routine physical examination made three months previously showed a positive agglutination to *Brucella abortus*. On December 8 a pure culture of *Brucella abortus* was obtained on serum agar medium (in $CO_2$ atmosphere).

External drainage was instituted on December 10 by rib resection and introduction of a drainage tube into the dependent portion of the empyema cavity. This was followed by a fall in temperature which reached normal on the fifth postoperative day. The cavity was irrigated daily with fresh Dakin's solution. The day following operation the cavity was capable of holding 250 c.c. of fluid; it was gradually becoming obliterated up to the eighteenth postoperative day, at which time a rise of temperature occurred, because of partial blockage of drainage, the result of a rising diaphragm. Free drainage was again established, after which there was a gradual and progressive subsidence of the infection. Daily irrigations of the cavity

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were continued, but closure was slow. Breathing exercises were performed by the patient, but it was not until Feb. 16, 1931 (sixty-eighth postoperative day) that the cavity was reduced sufficiently in size to warrant the removal of drainage. The patient was discharged two weeks later, x-ray films showing a fully expanded lung and complete obliteration of the cavity.

This patient was examined two years subsequent to discharge and again four years after discharge. Apart from some pleural thickening, x-ray pictures showed a negative chest.

## DISCUSSION

The clinical course was very similar to that of a streptococcus infection in that the fluid which was seropurulent at the first aspiration only very slowly and gradually became purulent. The delay in instituting drainage after the cavity became fixed was due to the persistent negative culture.

## CONCLUSION

In acute empyema with a culture repeatedly negative to pyogenic organisms, *Brucella abortus* as the primary causative agent should be borne in mind.

# A THORACOPLASTY RETRACTOR HARNESS

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ADEQUATE retraction in most surgical procedures is of the utmost importance. In the field of thoracic surgery, good retraction and sufficient exposure not uncommonly present a serious problem. One need only to observe the different types of retractors that are included in a chest surgery set-up to realize that good retraction must be considered important. But often satisfactory retraction is not obtained. Before an instrument is declared impractical or an assistant called lax, one should consider not only the adaptability of the retractor and the source of power behind, but also the correct application of both factors with the least effort.

During the past quarter century thoracoplasty has been added to the surgeon's therapeutic armamentarium in the treatment of certain stages of tuberculosis. In most clinics the posterolateral approach is the standard operative procedure for rib removal. In this approach it is of the greatest importance to elevate the scapula from the thoracic wall to insure adequate exposure for removal of any of the upper five ribs. Only when the incision is extended far enough laterally beneath and beyond the scapula, in this way dividing the fibers of the latissimus dorsi muscle, is the exposure of the ribs, which lie beneath the scapula, made easy. The assistant upon whom falls the task of holding the scapula out of the operative field receives the brunt of the criticism for failing to maintain sufficient retraction. Yet is he entirely to blame? Maintaining a pull sufficient to keep a scapula out of the surgeon's way from fifteen to thirty minutes is truly a Herculean task. Because of this difficulty, I undertook to see if an apparatus could be developed to aid the assistant in some way.

A canvas shoulder harness was made which could be worn by the assistant. This harness was patterned after a short sleeveless jacket and was made to fit snugly about the shoulders and upper back. Instead of the customary buttons and button holes in front, a one-inch width canvas belt was attached to each side of the front of the jacket by sewing the buckle end of the belt to the canvas just anterior to the arm holes. The other ends of the belts were allowed to hang free. A large harness buckle was threaded on to each belt and the free end of the belt brought through the belt buckle to form a closed loop.

From the Department of Surgery, University of Minnesota Hospitals, Minneapolis.
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The harness is sterilized by autoclaving, and the assistant slips it on over his sterile gown as one would put on a coat. The jacket can be left open in front when in use or the two flaps can be clamped together

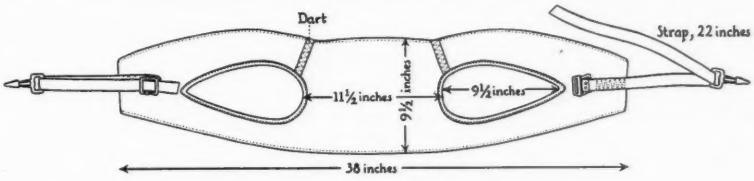


Fig. 1.—Posterior view of harness with anterior flaps pulled out straight.

Fig. 2.—Retraction harness in use.

by using a Backhaus clip. The harness buckles are snapped on to the end of a retractor which in turn is placed upon the scapula. White duck canvas of 8 oz. weight is used in making the harness (Fig. 1).

The harness is made up by the hospital seamstress at the cost of about one dollar. The assistant stands on the opposite side of the table from the surgeon and above the level of the patient's shoulder. In this position, with the retractor under the scapula, the pull is directed in a line which bisects a right angle formed by the patient's head and neck with the arm of the operated side abducted to an angle of 90°. The retractor will not slide off the scapula if this position is maintained. With the retractor in this position, the assistant needs to use his hands only as a guide because the necessary pull is produced by merely leaning backward into the harness and allowing the shoulders to do the work. In this way, the body weight is used to maintain the pull, thereby taking the strain off the arms of the assistant (Fig. 2).

In the method of rib removal which Wangensteen[1] has developed for thoracoplasty, it is not necessary to visualize the scapula and this retractor finds no place. Yet for those who are using the typical posterolateral approach, this type of retraction may serve as a satisfactory means of obtaining adequate exposure with facility.

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# TRANSTHORACIC PHRENIC NERVE INTERRUPTION

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WITH the widespread use of close thoracoscopy and pneumonolysis as an adjunct to pneumothorax therapy in pulmonary tuberculosis, the procedure of transthoracic phrenic nerve interruption may serve as a useful operative technique when carefully applied.

Pneumothorax collapse therapy, when used alone, is often inadequate to establish the closure of pulmonary cavities because of the presence of adhesions. The problem often arises whether to supplement the pneumothorax with a phrenic nerve interruption, or to perform a pneumonolysis to bring about the closure of the pulmonary cavities. Neither operation carries a very high morbidity and may be performed with impunity in most instances. The procedure at this institution is rather to perform a closed thoracoscopy whenever adhesions interfere with cavity closure, and by direct inspection to determine whether or not the adhesions may be severed. In some instances the severing of adhesions is impossible because of their size or their contents. When pneumonolysis is impossible and paralysis of the hemidiaphragm is desirable, the patient is submitted to a phrenic nerve interruption.

Recently, it has occurred to us that the closed thoracoscopy and phrenic crush operations may be accomplished as one operative procedure. With this thought in mind, in cases with hanging cavities, when the adhesions were too large to sever, an inspection of the mediastinal pleura was made and the phrenic nerve sought. In all instances the phrenic nerve cannot be seen. In cases with massive adhesions of the mediastinal and visceral pleura, the lung may conceal the nerve completely, or in cases where the pleura is covered with exudate, the nerve may be entirely concealed.

A definite attempt was made to crush the phrenic nerve through the thoracoscope in two instances, in one, on the right and in the other, on the left side. The instrument used was the ordinary long biopsy forceps of the Coryllos pneumonolysis set. The right transthoracic crush was performed as the nerve coursed downward over the vessels of the superior mediastinum. On the left side, the nerve was crushed as it coursed along the pericardium about 4 inches above the diaphragm. In both cases the patients complained of pain in neck and shoulder on the operative side. Immediately the diaphragm was seen to rise and its motion became markedly diminished and paradoxical in character. There were no untoward results noted in either case.

Case No. 1 was a white male, 56 years old, with a caseous pneumonic lesion in the right upper lobe. Pneumothorax was instituted on the right Aug. 10, 1937. Adhesions over right upper lobe prevented adequate control of the tuberculous lesion, and closed thoracoscopy was performed Oct. 2, 1937. The adhesion was too large to cut. The phrenic nerve was crushed by use of the long biopsy forceps, passed through the cannula. The nerve was crushed as it was seen proceeding along the large vessels of the superior mediastinum.

Case No. 2 was a white male, 27 years old, with a caseous pneumonic lesion in the left upper lobe, for which pneumothorax was instituted March 10, 1938.

From the Thoracic Surgery Service of Essex Mountain Sanatorium, Verona, N. J.
Received for publication Oct. 21, 1938.

Cavity closure was prevented by adhesions, and closed thoracoscopy was performed May 8, 1938. One lateral adhesion was severed, but the extreme apical adhesion was too large to sever. The phrenic nerve was then crushed as it passed along the pericardium, approximately 4 inches above the diaphragm.

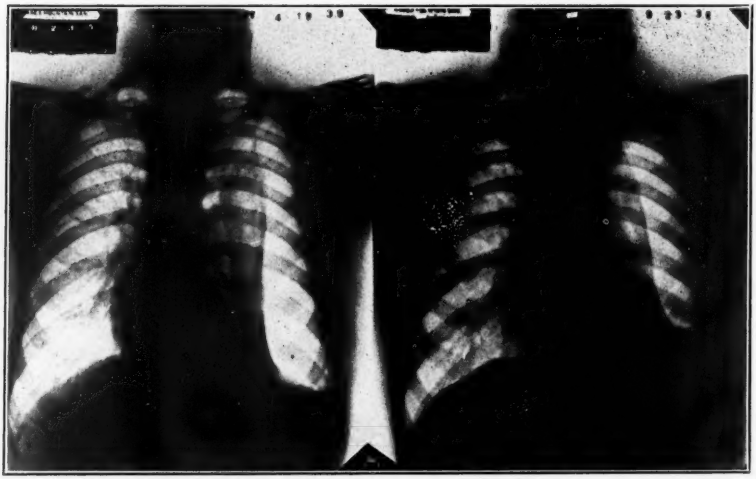

Fig. 1.—Case 2. X-rays taken before and after transthoracic phrenic nerve interruption showing rise of left diaphragm and closure of cavity following operation.

A phrenic nerve interruption at such a low level removes the possibility of any accessory nerves interfering with a complete paralysis of the diaphragm. The question of the duration of the paralysis is, however, an important one. One year has elapsed since the operation upon our oldest patient, and the diaphragm still remains paralyzed. The phrenic nerve interruption in this case was in the right superior mediastinum. In the second case the phrenic nerve was crushed about 4 inches above the diaphragm, on the left side. In this instance the diaphragm has remained paralyzed for the past five months.

We offer this means of interrupting the phrenic nerve as an additional procedure to be used in conjunction with closed thoracoscopy, whenever pneumonolysis is impossible and a paralysis of the hemidiaphragm is desirable.

Since this article was submitted we have performed transthoracic phrenic nerve interruptions on four additional patients with no untoward effects.

# STAB WOUND OF THE HEART WITH CORONARY LIGATION

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STAB wound of the heart necessitating coronary ligation is of infrequent occurrence. We are reporting such a case not because of its rarity but because of several features which we feel are of particular interest: first, the persistence of a loud systolic murmur heard over the entire chest without apparent diminution of cardiac reserve; second, complete absence of heart pain; and third, certain abnormalities in Lead IV of the electrocardiograms.

Approximately 600 cases of stab wound of the heart have been reported up to the present time. It is likely that there are many more injuries of this nature which have not appeared in the literature. The first reported case was that of A. Cappelan,[1] sutured unsuccessfully in Norway in 1895.

During the past year there have been six cases of stab wound of the heart admitted to the John Gaston Hospital. Of these, one patient was dead on arrival; the remaining five were operated upon with three survivals and two deaths, giving a mortality of 40 per cent, which roughly coincides with the mortality for this type of operation reported by other observers. Only one of these cases will be discussed since the others presented no unusual features which have not already been described adequately.

## CASE REPORT

E. M. (Fig. 1), negro male, aged 24 years, was seen Sept. 23, 1938, forty-five minutes after having been stabbed in the left chest with the long blade of a pocket knife. The patient was comatose on arrival, and his father, who accompanied him, gave the above information.

Examination revealed profound shock, with rapid, shallow respirations and cold, clammy skin. The pulse was imperceptible, and it was impossible to obtain his blood pressure. There was a stab wound 1 cm. long in the left sixth intercostal space just below the nipple. The point of maximal impulse of the heart could not be located. Percussion revealed precordial flatness, and on auscultation, the heart sounds could be heard faintly, but only at intervals. Distention of the cervical veins was marked. Fluoroscopic examination disclosed the typical signs of pericardial tamponade.

Stimulants were purposefully withheld, and blood was drawn for cross-matching with the blood bank.

The operation was performed by one of us (C. B. O.). Using novocain infiltration anesthesia, a trap door type of incision was made in the left chest with lateral retraction of the soft parts. The fourth, fifth, and sixth ribs were incised at their

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From the Departments of Surgery and Medicine of the University of Tennessee and of the John Gaston Hospital.

junctions with the sternum and retracted laterally. The internal mammary vessels were ligated at both the upper and lower ends of the wound. The left pleura was stripped from the pericardium, maintaining an intact pleural cavity and at the same time revealing a dark, bluish, distended pericardial sac. The pericardium was then opened and the free blood and clots were evacuated.

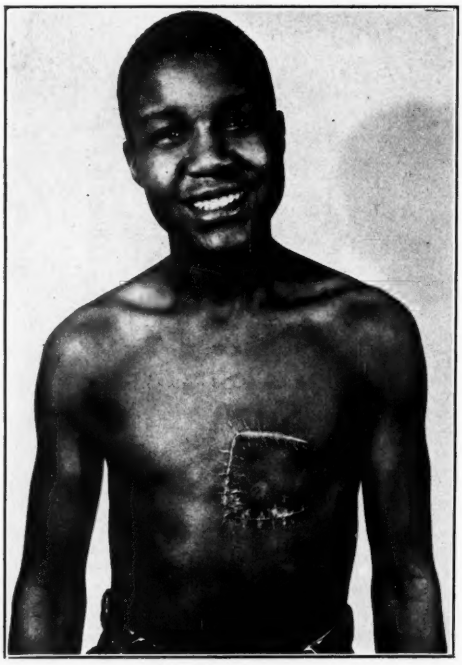

Fig. 1.—The patient three months after operation.

There was a laceration 1.5 cm. in length on the anterior surface of the left ventricle, approximately 2 mm. to the left of the left anterior descending coronary vessels and about 5 cm. from the apex (Fig. 2). The laceration penetrated the chamber of the left ventricle, and as soon as the tamponade was released, great streams of blood spurted. A silk traction suture was placed in the apex, as described by Beck,[2] in order to steady the heart. An attempt was made to close the laceration with silk sutures and to avoid the coronary vessels, but due to the narrow band of myocardium between the laceration and the vessels, this was found to be impossible, as the sutures pulled through the frayed muscle on two attempts. Because of the critical condition of the patient and the excessive blood loss taking place, it was thought unwise to make further efforts at preserving the coronary vessels. Four interrupted silk sutures were then placed so that the vessels were encircled and the laceration closed. An incision was made in the dependent pericardium to insure adequate drainage from the pericardium into the left pleural cavity, and the wound was closed tightly in layers with catgut. No external drainage was employed.

The usual elevation in blood pressure and improvement of pulse quality following release of tamponade were notably absent in this case. The patient, however,

experienced considerable relief when the blood was evacuated from his pericardial cavity, for he discontinued struggling and ventured the information that he felt much better. Following the placing of the first suture around the coronary vessels and until the pericardium was closed, an elapsed time of approximately ten minutes, the myocardium distal to the ligated vessels was carefully observed for signs of ischemia. No change in the color of the muscle was noted. The patient was questioned concerning the appearance of pain when the first suture was tied around the coronary vessels. He denied pain at that time or during the remainder of the procedure.

He was put to bed in the shock position and was given 400 c.c. of citrated blood. Stimulants, caffeine and ephedrine, were administered at regular intervals.

On the first postoperative day he still presented the picture of shock. The blood pressure was 70/40, and numerous extrasystoles were noted. Roentgenograms on this day revealed a moderate amount of fluid in the left pleural cavity. Thoracentesis was performed in the ninth left intercostal space, posterior axillary line, and 300 c.c. of blood were aspirated.

On the third postoperative day the blood pressure rose to 116/60; the pulse became rapid, full, and bounding, and a slight systolic murmur was heard over the apex. Evidence of consolidation was noted in the left lower lobe.

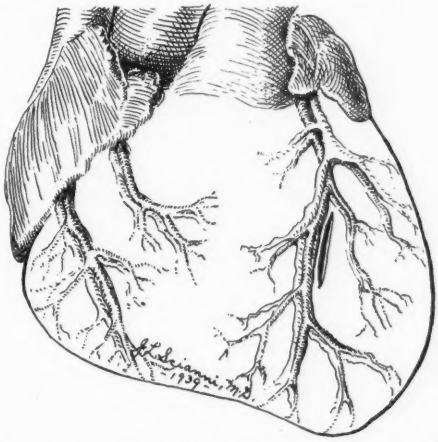

Fig. 2.—Sketch of the heart illustrating site and extent of the laceration.

The course for the next week was stormy, characterized by high, remittent fever and periods of delirium. The murmur became progressively louder until it could be heard over the entire chest, and a systolic thrill, of increasing intensity, appeared at the apex. This murmur will be discussed later. The signs and symptoms of pneumonia gradually subsided, leaving us concerned only with the cardiac condition.

The patient was kept at absolute bed rest on the ward for a period of six weeks. He was discharged seven weeks after operation feeling perfectly well.

On Dec. 12, 1938, approximately ten weeks after sustaining his injury, he went quail hunting against our instructions, walking about four miles in heavy boots and climbing numerous fences and hills without experiencing any discomfort.

He returned to light work three months after operation. Examination at that time revealed no change in the character of the systolic murmur and accompanying thrill.

## DISCUSSION

The systolic apical murmur with accompanying systolic thrill which developed on the third postoperative day and rapidly increased in intensity is worthy of discussion. At first it was faint, but within a few days it became loud and blowing, heard over the entire chest. The heart was thought to be slightly enlarged on physical examination, but this was not borne out by teleoroentgenograms. Therefore, cardiac dilatation was ruled out as the cause of the murmur.

It is highly improbable that valvular disease was responsible for the murmur as the patient gave no history of rheumatic infections, had no stigmas of this disease, was not arteriosclerotic, and had no cardiac symptoms prior to injury.

The absence of anemia and the character of the bruit itself made it unlikely that the murmur was of hemic origin.

The possibility of a left ventricular mural thrombus on the infarcted endocardium was considered and a careful vigil for embolic phenomena kept. The absence of such phenomena suggests that a mural thrombus was not present, but, of course, does not absolutely disprove its presence.

An aneurysm of the left ventricular wall was suspected, but repeated fluoroscopic and roentgenographic examinations failed to demonstrate this complication. Three months after operation, when the systolic murmur and thrill were unchanged in character, a kymographic tracing was completely negative.

We are at a loss to explain this murmur unless the point of the knife, in penetrating the left ventricular chamber, injured the mitral valve, the chordae tendineae, or the papillary muscle. It is possible that this occurred, as the blade entered the chest wall in the sixth intercostal space and penetrated the left ventricle 5 cm. above the apex, indicating that the weapon slanted upward in its course.

The absence of pain in this case is particularly interesting and deserves full discussion. We are prepared to offer an explanation for its absence.

Dogiel,[3] in 1891, first observed that coronary arteries, like most arteries, have sensory nerve endings in their adventitia. In 1926 Woollard[4] demonstrated that the nerves leading to and from the ventricles form a loose network around the coronary blood vessels. Katz et al.,[5] taking advantage of the above observations, proved conclusively in 1935 by carefully conducted animal experimentation that ischemia alone cannot adequately explain the occurrence of pain in coronary occlusion. Working on dogs, they isolated the nerve plexuses which course along the adventitia of the left anterior descending coronary artery. With such an animal preparation they were able to show that occlusion of the portion of the coronary artery which

was separated from its nerve supply did not induce typical signs of cardiac pain; however, evidence of pain was noted when the undissected coronary vessels above or below this point were compressed. Katz and his co-workers further observed that the pain response to compression was abolished if the nerve plexus was destroyed with phenol and alcohol, yet a positive response occurred when a region above the phenolized area was occluded. These experiments seem to prove very definitely that the integrity of the nerve plexus surrounding the coronary artery is necessary in order to convey pain impulses from an infarcted myocardium to the central nervous system.

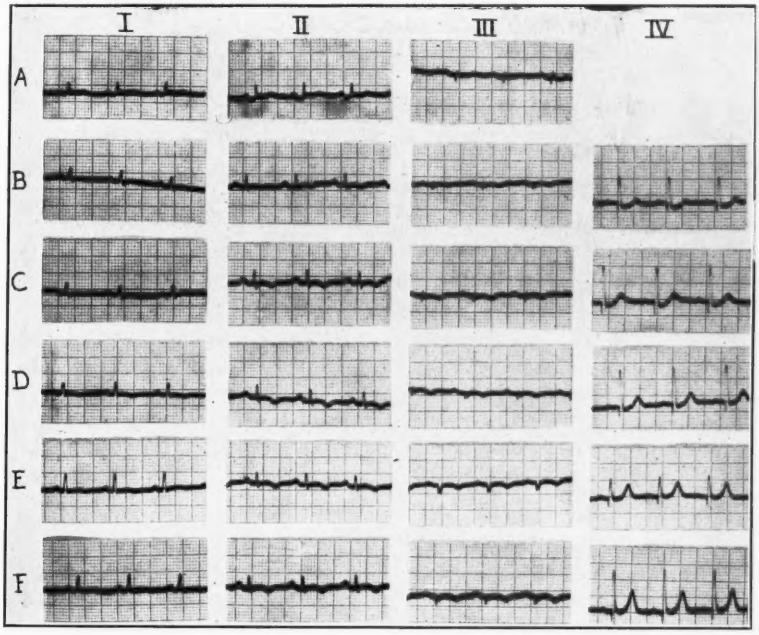


Fig. 3.—Serial electrocardiograms demonstrating appearance and disappearance of changes characteristic of anterior myocardial infarction. Record A was taken five days after operation; Record B, on the thirteenth day; Record C, on the fifteenth day; Record D, on the twentieth day; Record E, on the fortieth day; and Record F, on the forty-seventh day. Roman numerals indicate leads.

We feel that the quadruple ligation of the left anterior descending coronary vessels incorporated and destroyed the nerve plexus in our patient, thus fully accounting for his complete absence of cardiac pain.

Since Davenport's[6] report in 1924 on the appearance of typical electrocardiographic curves following ligation of a branch of the left descending coronary artery and vein, similar reports have been published, notably those of Elkin and Phillips,[7] Porter and Bigger,[8] Koucky and Milles,[9] and Davenport et al.[10]

Serial electrocardiograms were taken almost daily of our patient during his stay in the hospital and at less frequent intervals after his discharge. Fig. 3 reveals the changes that occurred.

Record A, taken five days after operation, shows a slightly elevated ST take-off in all three leads, which suggests pericardial reaction to the injury. $T_1$ is positive but of low amplitude; $T_3$ is likewise small and upright. The QRS complexes all show low voltage, those in Leads I and II being positive and monophasic, those of Lead III diphasic.

Record B, taken thirteen days after operation, presents several interesting features. $ST_1$ has dropped slightly below the isoelectric level and its contour is assuming the classical Pardee pattern with convexity upward followed by inverted $T_1$. This confirms what has been emphasized repeatedly in the literature, that the earliest electrocardiographic manifestation of coronary infarction is deviation of the ST segment, and that changes in the contour of the ST segment and inversion of T waves occur later, frequently after the deviation has disappeared. Definite Pardee coronary waves have developed in Lead II and less distinctly in Lead III.

It should be noted that Lead IV in these serial electrocardiograms was taken with the positive electrode applied anteriorly in the fifth intercostal space over the apex and with the negative electrode applied to the left leg, a technique which does not conform to the recommendations of the Committee on Standardization of the Fourth Lead. Bearing this in mind, it is seen that a definite $Q_4$ is present in Record B and that $T_4$ is upright.

Records C and D, taken fifteen and twenty days, respectively, after operation, show the progression of electrocardiographic changes associated with anterior myocardial infarction. $ST_1$ on the twentieth postoperative day is back to the isoelectric level. In the classical leads, deeper coronary waves are present and $T_4$ is increasing in height. $Q_4$ is still distinctly present and well above 2 mm. in depth. Waves of the $Q_1$ type, which so frequently occur in anterior coronary occlusion, are conspicuously absent, nor, as will be seen later, did they ever appear while the patient was under observation.

Forty days after operation, left axis deviation began to develop, as inspection of Record E reveals. $R_1$ is distinctly greater than $R_2$, and $S_3$ is present. $QR\text{-}S_3$ is entirely negative now and of a W configuration. The ST segments in all leads continue to show definite evidence of anterior myocardial infarction.

On the forty-seventh day after injury, Record F demonstrated the return of $T_1$ to positive, while $T_2$ and $T_3$ remained sharply inverted and coved. $T_4$ is growing progressively taller. $Q_4$ is still present.

Davenport et al.[10] were the first to describe changes in the fourth lead due to artificially induced anterior myocardial infarction in man. We are the second to make such observations. By a striking coin-

cidence, $Q_4$ persisted in their patient as well as in ours. Although such a wave is absent in the great majority of anterior infarctions, it may be present in rare cases, as Barnes and Wolfram[11] recently pointed out.

Summarizing our electrocardiographic findings, serial tracings in four leads revealed the appearance and disappearance of changes due to anterior myocardial infarction. It is proved quite definitely that such infarction does not necessarily produce a $Q_1$ and that $Q_4$ may persist.

SUMMARY

1. A case of stab wound of the heart with ligation of the left anterior descending coronary vessels is reported.

2. The development of a loud systolic murmur heard over the entire chest is discussed. It is thought that the blade of the knife injured the mitral valve, the chordae tendineae, or the papillary muscle, thus causing mitral insufficiency.

3. The absence of cardiac pain following ligation of coronary vessels is explained.

4. Serial electrocardiographic studies, showing changes due to anterior myocardial infarction, are presented.

5. Abnormalities in the fourth lead in artificially induced coronary occlusion in man are described for the second time.

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# STAB WOUND OF THE PULMONARY VEIN

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INJURIES to the pulmonary vein are rarely seen except on the autopsy table. In a survey of the literature I could find only four cases recorded. Two were stab wounds and two gunshot wounds. Two were of the left superior and two of the right superior pulmonary vein. All were reported from Germany. The rarity of this condition makes the following case of interest.

E. F., male, negro, aged 22 years, was admitted to the hospital July 17, 1938, after being stabbed in the left side of the chest in a fight. He was in a state of shock, although there had been little external bleeding. His skin was cold, clammy, and sweat-covered. Mild hemoptysis was present. The pulse was very weak and, contrary to expectations, the rate was only 78. The blood pressure was 70/40. Examination showed a stab wound three-fourths of an inch long, over the second left intercostal space in the midclavicular line. Little bleeding was present. Surrounding the wound was a small area of subcutaneous emphysema. The left side of the chest was dull throughout, with absence of breath sounds. The heart sounds were very poor and barely audible, and the condition of the patient was growing rapidly worse. A diagnosis of massive intrapleural hemorrhage was made, and preparations for operation were started immediately. A roentgenogram showed clouding of the entire left chest except for a small pneumothorax.

With the patient under gas-oxygen-ether anesthesia, a horizontal incision was made on the left side just below the stab wound, and 4 inches of the third rib was resected. When the chest was opened through the length of the rib bed, there was a considerable outpouring of partly clotted blood. More was removed by suction and sponging, although some remained behind and below the lung. The total quantity in the chest was approximately 2 liters. The fourth costal cartilage was cut across at the medial end of the opening, retraction then permitting easy inspection of the pleural cavity. The lung was completely collapsed. The heart and pericardium were intact. No injury to the lung was found although the hemoptysis made such an injury fairly certain. The region of the hilus of the lung was exposed and a longitudinal laceration three-fourths of an inch long was found in the superior pulmonary vein where it passes from the lung to the left auricle of the heart. The vein at this point is covered only by the pleura. From the wound a small, steady stream of blood was flowing. The wound was closed with three interrupted sutures of fine chromic catgut, everting the edges. No further bleeding occurred and no other injury was found. The pleural cavity was closed by suturing the upper lobe of the lung to the edges of the opening, making it airtight. Over this was sutured muscle. The wound was then packed with iodoform gauze, over which the skin was sutured. At intervals throughout the operation, the chest opening was closed with hot, wet pads to arrest the shifting motion of the mediastinum and thus help maintain some stability of the respiration and circulation. A transfusion followed by an infusion was given as soon as the injured vessel was closed.

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From the Surgical Service of Harlem Hospital, Dr. Louis T. Wright, Director.

Recovery was attended by occasional attacks of dyspnea due to accumulations of air in the pleural cavity. These were treated by underwater decompression. The blood remaining in the chest was not absorbed for several weeks. Otherwise, convalescence was uneventful.

## COMMENT

Massive intrapleural hemorrhage developing rapidly is due to injury to the heart or one of the large vessels leaving or approaching it. A similar hemorrhage from a vessel of the chest wall develops more slowly. In any such case, if examination of the heart and pericardium does not reveal an injury, the region of the hilus of the lung should be investigated. Injury to the pulmonary vein is rare because of the location of the vessel. However, its possibility must be borne in mind. Treatment presents no difficult or unusual features to anyone accustomed to chest surgery.

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# TUBERCULOMA OF THE LUNG

## Case Report

Cameron Haight, M.D., and J. Matthews Farris, M.D.
Ann Arbor, Mich.

AN UNUSUAL calcified pseudotumor of the lung, of interest because of its attending diagnostic and therapeutic problems, is described since the pathologic evidence in this case is of aid in clarifying the etiology of lesions of this type. The tumor, discovered accidentally during roentgenologic studies of the gall bladder, was a calcified, sharply circumscribed mass situated immediately above the right leaf of the diaphragm. The outstanding characteristic of the density, as viewed roentgenographically, was the arrangement into concentric laminations. The patient had first consulted his physician because of pain along the right costal margin and in the right upper quadrant of the abdomen, of sufficient intensity to cause him to stop work. Although there were no pulmonary or thoracic symptoms other than pain, the lesion strongly resembled a pulmonary tumor. Diagnostic difficulties were increased by the fact that the patient had resided for four years in South America, suggesting the possibility of a calcified hydatid cyst. Because of the resemblance of the mass to a pulmonary tumor and more especially because of the severity of the pain, operation was advised. The lesion encountered at operation was puzzling; the mass itself was dense and intimately included in pulmonary tissue, although the adjacent pulmonary tissue was notably free of reaction and there were no pleural adhesions. Resection was accomplished uneventfully and pathologic studies subsequently proved conclusively that the lesion was a calcified tuberculoma.

Three cases of calcified pulmonary abscess simulating tumor were described by Graham and Singer[1] in 1936. At the time of their study they were unable to find any similar cases in the literature, and the true nature of the pathologic process was obscure in all their cases. Although tuberculosis was mentioned as a possibility, they believed the pathologic evidence was insufficient to justify this diagnosis. The description and published photographs of the gross and microscopic specimens of two of their cases so closely resemble the findings in the case to be described that it is believed the lesions are identical. Whereas a positive diagnosis could not be made in Graham's and Singer's

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cases, it is felt that the evidence in our case conclusively proves that this type of lesion is a tuberculous one.

*Case History.*—W. W., white, engineer, age 49 years, was referred by Dr. A. V. Tubbs, of Blissfield, Mich., for treatment of an intrathoracic "tumor" which he had accidentally discovered during a cholecystogram. The patient stated that he had been perfectly well until about two weeks prior to admission when, for the first time, he experienced severe pain in the lower right chest upon arising in the morning. The pain characteristically began at the spine and radiated to the right costal margin and right upper abdominal quadrant, was augmented somewhat by respiratory excursions, and was also made worse by the sitting position. At first, he worked as usual although he was forced to restrict his activities considerably because of the pain. Severity of symptoms progressed until the patient was forced to stop work. There were no associated cough, hemoptysis, dyspnea, chills, fever, or other signs of systemic disease. Repeated interrogations failed to bring out any history of previous symptoms referable to the respiratory tract at any time in the patient's life.

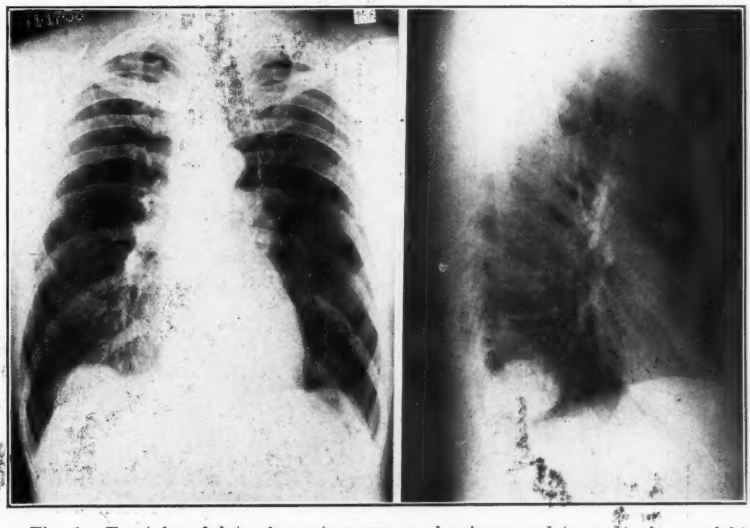

Fig. 1.—Frontal and lateral roentgenograms showing pseudotumor in lower right chest. The frontal projection shows slight scarring in the extreme apices, more so in the left apex, and calcified right hilar lymph nodes. Calcified subcarinal nodes are evident in the lateral projection and are seen more clearly in the oblique projection. (Fig. 2*A*).

The physical examination revealed a well-developed adult male in no evident distress. With the exception of a blood pressure of 155/97, there were no abnormal physical findings. The urine, erythrocyte count, leucocyte count and hemoglobin were normal. Moderate basophilic stippling of the polymorphonuclear leucocytes was noted in the differential count. The routine blood Kahn was negative. No sputum was available for examination. Intradermal injection of 0.1 c.c. of first strength protein derivative of purified tuberculin gave a markedly positive reaction (postoperative observation).

Roentgenographic examination disclosed a 6 cm., partially calcified, rounded mass which was partly obscured by the diaphragm. In the lateral and oblique

projections the mass could be localized in the posterior right thoracic cavity. Concentric laminations were seen in the right anterior oblique films and in frontal projection films made through the Potter-Bucky diaphragm. Fluoroscopy revealed that the mass moved with the lung. There was extensive calcification in the right hilar and subcarinal nodes which was considered as evidence of healed tuberculosis.

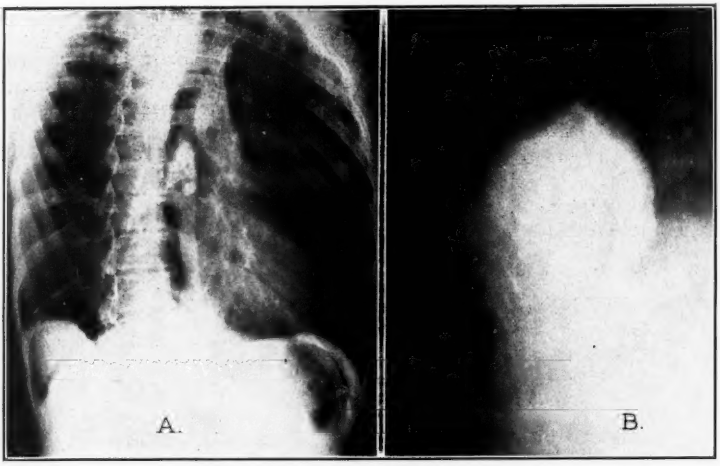


Fig. 2.—The laminated central portion of the tuberculoma is seen in the right anterior oblique projection (*A*) and in the frontal projection film made through a Potter-Bucky diaphragm (*B*).

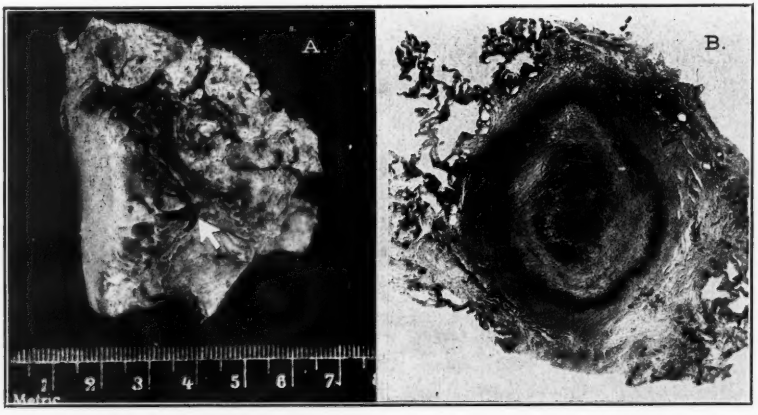


Fig. 3.—(*A*) Tangential view of tuberculoma and resected portion of lower lobe after fixation. The silk sutures (indicated by arrow in *A*) indicate the site of the fibrocalcareous tubercle (×18) which was removed for frozen-section biopsy (*B*).

There was also minimal scarring in the left apex and in the axillary portion of the right lung. The preoperative roentgen diagnosis was "a calcified pulmonary tumor, probably a large tuberculoma" (Dr. V. C. Johnson, Department of Radiology).

On Jan 27, 1938, under avertin and nitrous oxide oxygen anesthesia, an exploratory thoracotomy was performed through an incision in the eighth intercostal space.

The eighth and ninths ribs were divided posteriorly and segments 2 cm. long were removed to increase the exposure. A smooth and glistening, dense, pale yellow mass presented on the posterior and diaphragmatic surfaces of the right lower lobe. No adhesions were present but there were soft, fleshy, cystic granulations on the parietal pleura in the region where the tumor mass had been in apposition with the thoracic wall. Also, a somewhat similar area was present on the diaphragm; here, the granulations were firm and partly calcified. Frozen-section biopsy of the parietal pleural granulations showed chronic nonspecific inflammation. The diaphragmatic granulations were not biopsied. A small, grayish, dense, and apparently calcified

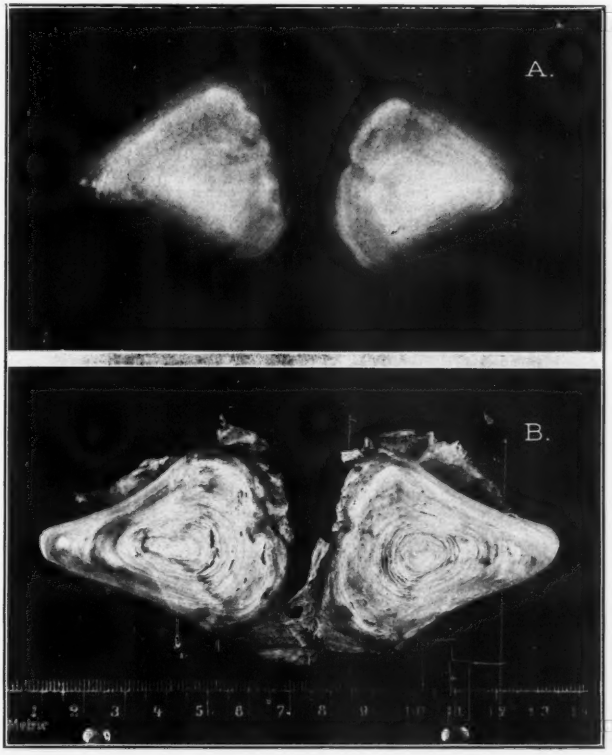


Fig. 4.—The calcified concentric laminations and the calcified nucleus are evident in the roentgenogram (*A*) and photograph (*B*) of the tuberculoma after resection.

subpleural pulmonary nodule approximately 0.5 cm. in diameter was present about 3 cm. anterior to the larger mass. This nodule was removed for frozen-section which showed it to be a fibrocalcareous tubercle. Because the pain had been sufficiently severe to cause the patient to discontinue work and because it was felt that the symptoms in the main were due to a traumatic pleuritis caused by the presence of the mass, resection was thought to be indicated. As there did not appear to be a satisfactory cleavage plane between the mass and the adjacent lung, long-length hemostats were placed serially across the lobe proximal to the mass, which was then

removed in conjunction with a several-centimeter thickness of pulmonary tissue, which included the site of the previously removed subpleural nodule. In the central portion of the transected pulmonary tissue, a bronchus and several small vessels were individually clamped and ligated with silk. The cut surface of the lung was closed with a continuous catgut suture. Considerable puckering resulted, reducing the lobe to about one-third its normal size. The phrenic nerve was gently crushed three cm. above the diaphragm in order to compensate for the loss of volume in the lung and also to act as a therapeutic measure should a tuberculous effusion develop. There was no leakage of air at the completion of the resection. The thoracic wound was closed without drainage. Convalescence was uneventful except for a sterile pleural effusion which was aspirated on several occasions. The period of hospitalization was prolonged for management of the effusion, and the patient was discharged on the thirty-ninth postoperative day. A recent communication (Jan. 18, 1939) from the patient states that he is feeling well and has been working regularly since April 19, 1938. An occasional pain is felt in the right upper abdominal quadrant, but its duration is so short that it is not bothersome. Fluoroscopic examination by Dr. Tubbs on Dec. 10, 1938, was negative except for slight thickening of the pleura.

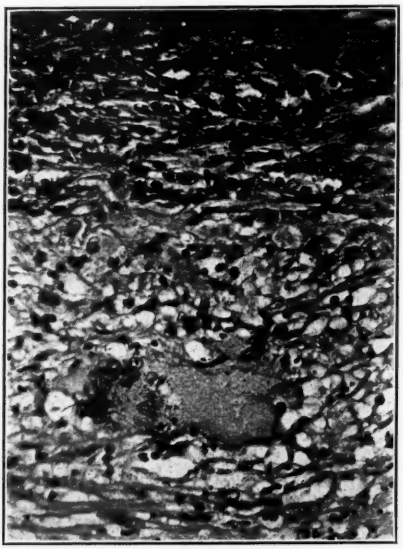

Fig. 5.—Area of living tissue at periphery of tumor showing active tuberculous infection (×495).

On examination, the lesion was a smooth, pale yellow, stony hard, spherical mass measuring 6.5 cm. in its greatest diameter, and on section, calcific deposits arranged in definite concentric rings could be seen. The microscopic report, made by Dr. C. V. Weller, is as follows: "A large tumor mass with a laminated structure made of dense connective tissue bands with alternate layers of calcium deposition. The calcium in many areas presents a pattern suggesting that it has been laid down in a spindle-celled stroma. The adjacent pulmonary tissue shows patchy atelectasis and numerous pigment-containing phagocytes in the alveolar spaces. Diagnosis: The lesion is an old tuberculous focus and there are a few younger active tubercles

at the periphery of the mass.'' Fig. 5 shows one of the younger tubercles at the periphery of the mass and one of its contained giant cells. Carbolfuchsin stains of the tissue were negative for acid-fast bacilli, and cultures for pyogenic organisms and acid-fast bacilli made directly from the tumor showed no growth.

The lesion, on chemical examination, contained 35.47 per cent ash. Of the ash, 43.75 per cent was calcium and 17.99 per cent was phosphorus. These figures correspond quite closely to those in the cases of Graham and Singer.

| | Ca % | P % |
|---|---|---|
| Graham and Singer: | | |
| Case 1. | | |
| In ash | 37.3 | 19.2 |
| In dry material | 9.4 | 4.9 |
| Case 2. | | |
| In ash | 37.9 | 15.1 |
| In dry material | 8.8 | 4.4 |
| Haight and Farris: | | |
| In ash | 43.7 | 17.9 |
| In dry material | 15.3 | 6.2 |

When the ash was dissolved, there was a considerable amount of effervescence, indicating the presence of carbonate also. If one calculates the phosphorus as calcium phosphate, it is found that of the calcium present, 79.2 per cent can be accounted for as in combination with the phosphorus present (Prof. H. B. Lewis, Department of Biological Chemistry).

## COMMENT

A wide variety of intrathoracic lesions may contain calcium salts which are deposited as elsewhere in the body according to the universal principle that necrotic tissues which cannot be absorbed will become impregnated with calcium salts. More rarely, calcified lesions within the lung may eventually become transferred into true bone, not only with bone corpuscles and Haversian canals, but with typical marrow.[2] Although pulmonary tuberculosis is of relatively common occurrence, large tuberculomas similar to the one described are rare. It is not unusual, however, to see smaller round lesions of tuberculosis without calcification, which sometimes resemble tumors radiographically.

Calcific deposits occurring in tuberculosis do not differ in composition from those occurring in other pathologic conditions. Wells[3] states that the composition of the inorganic salts in calcified areas in the body seems to be practically the same, if not identical, whether the salts are laid down under normal conditions (ossification) or under pathologic conditions. A circumscribed tuberculous lesion undergoing slow peripheral extension and concurrent calcification of centrally contained necrotic tissue would conceivably produce a tuberculoma similar to the one described here. Weller[4] believes that such an explanation best fits the pathologic picture observed in this case. Sweany, Tillotson, and Kozielek[5] believe that the retrogressive changes occurring in a tubercle start with autolysis of the central core with liberation of many acid radicals which combine with calcium ions already present

or diffusing in from the body fluids. The calcification continues outward, wave upon wave, each new ring perhaps depending upon the further production of acid radicals within peripherally extending concentric zones of tuberculous necrosis. Sweany[6] has illustrated this phenomenon in a microphotograph of a subpleural nodule occurring in tuberculosis.

The most striking roentgenographic characteristic of the lesion in the case reported is the presence of the concentric laminations. The published photographs of two of the tumors removed by Graham likewise exhibit this characteristic. The third case of Graham and Singer was unlike their first two cases and the one described in this article, in that the central portion of the mass was occupied by material which seemed to be thick, creamy pus. The microscopic examination of the material, however, showed no evidence of pus. The central cavity was lined with ciliated epithelium which in turn was surrounded by thin plates of true bone.

Marked pulmonary symptoms are not a consistent feature of the disease. It is of interest that the tumor was accidentally discovered during roentgenologic examination of the upper abdomen in the case here reported and in Graham's and Singer's Case 2. In both these cases, pain was the only symptom. In our case, it is believed that the pain was entirely of pleural origin. Although a copious amount of sputum was present in Graham's and Singer's Case 1, they believed it was due to an associated bronchiectasis, but they did not have an opportunity to verify this diagnosis, inasmuch as the patient was treated before lipiodol was available.

The possibilities of a complicating tuberculous effusion following operation should be considered. The experimental observations of Griffith[7] show that the life of tubercle bacilli in a retrogressive lesion may be relatively brief and that old encapsulated lesions rarely, if ever, contain living tubercle bacilli. Feldman and Baggenstoss[8] are of the opinion that the lesions of the primary complex of tuberculosis, when definitely encapsulated and sclerotic, or caseous or caseocalcareous, seldom contain viable or virulent tubercle bacilli. They examined for the most part caseous and caseocalcareous Ghon tubercles or similarly affected tracheobronchial lymph nodes obtained at autopsy from sixty-eight unembalmed bodies of persons who had died from causes other than tuberculosis. One hundred and three emulsions from individual lesions were studied, and each emulsion was used to inject two guinea pigs and to prepare eight cultures. They were able to demonstrate tubercle bacilli in only one lesion. Conflicting evidence is found in the case of a large tubercle, mistaken for a neoplasm, which was reported by Jacobaeus and Key.[9] The lesion presented at the surface of the upper lobe and in the interlobar fissure. The roentgenologic

examination showed an even, sharply outlined shadow without a condensed edge and without induration in the surrounding pulmonary parenchyma. Unlike the case described in this article, calcification and laminations were absent. A block resection of the tumor was performed. During the resection, a "discharge of matter" occurred from two divided bronchi. An additional small portion of lung was also removed because of residual granulations. On examination, the tumor was composed of fibrous tissue and areas of necrosis. Giant cells of the typical Langhans type were found in a layer of granulation tissue at the edge of the tumor, and on staining with carbolfuchsin, occasional tubercle bacilli were seen. The patient died after developing a tuberculous abscess of the wound. At autopsy a tuberculous pleurisy with miliary tubercles was found.

A block resection of the tumor and adjacent pulmonary tissue was done in our case because there did not appear to be a satisfactory cleavage plane between the mass and adjacent pulmonary tissue. Furthermore, the biopsy report of the adjacent nodule demonstrated it to be tuberculous, and, therefore, it was believed that the possibility of inciting a tuberculous effusion would be lessened by performing a wide resection which would include the site of the small excised nodule. In retrospect, a block resection seems preferable to enucleation as there were active tubercles and chronic tuberculous granulation tissue at the periphery of the large tuberculoma, whereas there was no tuberculous involvement of the lung at the site of the transsection.

## SUMMARY

An unusual calcified pseudotumor of the lung which was subsequently shown to be a tuberculoma is described since the pathologic evidence in this case is of aid in clarifying the etiology of this type of lesion. The mechanism of calcification in tuberculomas of this type is discussed. The concentric calcific laminations result from an outward progression of zones of necrosis with subsequent calcification. This phenomenon, so strikingly apparent in this case, was also seen in lesions reported by Sweany and by Graham and Singer. Since calcified lesions are usually devoid of contained tubercle bacilli, it would seem that resection might be undertaken without great danger of a complicating tuberculous effusion. The technique of block resection appears to be preferable to that of enucleation because of the possibility of there being active tubercles at the periphery of these lesions.

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# The American Association for Thoracic Surgery

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## The American Association for Thoracic Surgery

The twenty-second annual meeting of the American Association for Thoracic Surgery was held in Los Angeles, Calif., July 5, 6, and 7, 1939.

Dr. Adrian V. S. Lambert of New York, N. Y., was elected president for the coming year. Dr. Fraser B. Gurd of Montreal was elected vice-president. Dr. I. A. Bigger of Richmond, Va., Dr. Richard H. Meade, Jr., of Philadelphia, Pa., and Dr. Evarts A. Graham of St. Louis, Mo., were re-elected to the following offices, respectively: treasurer, secretary, and editor of THE JOURNAL OF THORACIC SURGERY.

The resignation of Dr. James Greenough was accepted with regret.

The following members were advanced from active to senior membership: Dr. Frank K. Boland, Dr. James A. Miller, Dr. DeWitt Stetton, Dr. Gerald B. Webb, Dr. Stuart Pritchard, and Dr. Samuel Harvey.

The following associate members were advanced to active membership: Dr. Duane Carr, Dr. Louis R. Davidson, Dr. Howard K. Gray, Dr. John C. Jones, Dr. L. J. Leahy, Dr. John Strieder, and Dr. Grant Thorburn.

The following men were elected to associate membership: Dr. Clifford Benson, Detroit, Mich.; Dr. Reeve H. Betts, Brookline, Mass.; Dr. Brian Blades, St. Louis, Mo.; Dr. J. Claude Day, Detroit, Mich.; Dr. William E. Delaney, Jr., Williamsport, Pa.; Dr. Richmond Douglass, Ithaca, N. Y.; Dr. James Forsee, Washington, D. C.; Dr. John H. Garlock, New York, N. Y.; Dr. Paul Gebauer, Cleveland, Ohio; Dr. Edwin J. Grace, Brooklyn, N. Y.; Dr. Frederick Kergin, Toronto, Canada; Dr. Charles W. Lester, New York, N. Y.; Dr. Carl G. Merkel, Mount Morris, N. Y.; Dr. Felix Miller, El Paso, Texas; Dr. James L. Mudd, St. Louis, Mo.; Dr. Forrester Raine, Milwaukee, Wis.; Dr. Arthur M. Vineberg, Montreal, Canada; and Dr. Arthur Vorwald, Saranac, N. Y.

Dr. John B. Barnwell, Ann Arbor, Mich., was elected to active membership.

The following amendments to the constitution were proposed and will be acted upon at the next meeting:

Article V, Section 2, which at present reads, "Officers and Councilors shall be elected at the annual meeting of the Association, and shall take office on the first day of January, next succeeding . . ., etc.," shall be changed to read, ". . . shall take office upon conclusion of the meeting."

Article VII, Section 1, which now reads, "The fiscal year of the Association shall coincide with the calendar year . . ., etc.," shall be changed to read, "The fiscal year of the Association shall run from the beginning of one annual meeting to the beginning of the next annual meeting. . ."

Article VII, Section 4, which now reads, "All funds derived from the payment of initiation fees shall be placed in a special fund, to be invested and reinvested in legal securities, and to be held intact as an Endowment Fund. The Council is responsible for the proper management of the Endowment Fund. The income from this fund may be utilized for such purposes as may be determined in the By-Laws. If at the end of any fiscal year there be a surplus in the current funds of the Association, the Council may divert such surplus in to the Endowment Fund, but in no case may the Council divert any of the principal of the Endowment Fund into the current account of the Association. . . .," shall be changed to read: "Article VII, Section 4: All funds derived from the payment of initiation fees shall be placed in a special fund, to be invested and reinvested in legal securities, to be held intact and to be known as the Endowment Fund. The Council is responsible for the proper management of the Endowment Fund, and may divert any surplus in the current funds of the Association into this fund, but may not withdraw any of the principal of the Endowment Fund except in accordance with the provisions of Section 6, following:

"Article VII, Section 5: The income from the Endowment Fund shall be expended as the Council directs.

"Article VII, Section 6: The principal of the Endowment Fund may be withdrawn, in whole or in part, under the following conditions only: the amount of principal to be withdrawn shall have been approved by the Council; it shall have been approved by a majority of the members present and voting at a regularly convened annual meeting; it shall have been then tabled for one year; it shall have been finally passed by a three-fourths vote of the members present and voting at the next regularly convened annual meeting."

The by-laws were amended as follows: Article VI, Section 5, providing for a Necrology Committee was deleted. Article VII, Section 2, which reads, "Annual dues for Active Members shall be $10," was changed to read $12.50. Section 3 which reads, "Annual dues for Associate Members shall be $3," has been changed to read $5.

It was announced that the Rose Lambert Graff Foundation had offered the Association a sum of $250.00 to be given as a prize for the best paper submitted for the 1940 meeting. This competition is to be open to any reputable physician in the United States or Canada. The paper is to be submitted to a committee composed of Dr. Adrian V. S. Lambert, Dr. J. J. Singer, Dr. Fraser Gurd, Dr. Claude Beck, Dr. Evarts A. Graham, and Dr. Richard H. Meade, Jr., and must be in the hands of the secretary, Dr. Richard H. Meade, Jr., 2116 Pine Street, Philadelphia, Pa., before March 1, 1940.

The next meeting of the Association will be held in Cleveland, June 6, 7, and 8, 1940.